

BOTSWANA LOCUST CONTROL PROGRAM:
SUPPLEMENTARY ENVIRONMENTAL ASSESSMENT

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
MISSION TO BOTSWANA
IN COOPERATION WITH THE GOVERNMENT OF BOTSWANA

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PREFACE

This document is a supplement to the Programmatic Environmental Assessment (PEA) concerning USAID assistance in locust/grasshopper control programs. This Supplementary Environmental Assessment (SEA) was prepared by USAID/Botswana and a specialist provided by USAID/W (AA/AFR/DRC), along with support from the Government of Botswana (GOB). Document preparers and contact persons are listed in Appendix A.

The document has been reviewed by USAID/Botswana, USAID/W, and the Government of Botswana. It reflects the best current description of future options for USAID assistance to the Botswana Plant Protection Division for locust/grasshopper (l/g) management. The document also presents the best available estimates of human health and environmental risks associated with l/g control operations, along with possible mitigating strategies. Mitigation may include training programs covering improved health and environmental protection, as well as support for early survey and spot treatment programs. Encouragement is given for use of alternatives to chemical pesticides, along with prudent and environmentally sound use of pesticides when these materials are necessary. Commitments for any possible future program are contingent on future needs for l/g control, the capabilities of the Botswana Plant Protection Division of the Crop Production and Forestry Department of the Ministry of Agriculture (PPD/CP&F/MOA), and on a decision by USAID to provide assistance.

While the document primarily concerns l/g management of populations entering from the northern regions and southern borders of Botswana, it may also serve to guide control efforts for other pests in other parts of the country, given the gathering of appropriate additional information.

ACRONYMS AND ABBREVIATIONS

ACHe	AcetylCholinesterase
AELGA	African Emergency Locust/Grasshopper Assistance Project - USAID/Washington
BMS	Botswana Meteorological Services
CFR	US Code of Federal Regulations
CP&F	Crop Production and Forestry Department, MOA
DRC	Disaster Response Coordinating Unit, Africa Bureau, AID/W
DWNP	Department of Wildlife and National Parks, GOB Ministry of Commerce and Industry
EA	Environmental Assessment
EPA	US Environmental Protection Agency
FAO	United Nations Food and Agriculture Organization
GIFAP	Groupeement International des Associations nationales des Fabricants de Produits Agrochimiques
GOB	Government of Botswana
ha	hectare
IGR	Insect growth regulator
IPM	Integrated Pest Management
IRLCO-CSA	International Red Locust Control Organization--Central and Southern Africa
km	kilometer
l/g	locusts/grasshoppers
MOA	Ministry of Agriculture, GOB
NCS	National Conservation Strategy, GOB
NORAD	Norwegian Agency for Development Cooperation
ODA	United Kingdom Overseas Development Association
PEA	Programmatic Environmental Assessment
PPD	Plant Protection Division, Department of Crop Production and Forestry, MOA
RSA	Republic of South Africa
REDSO	Regional Economic Development Support Office
SARCCUS	Southern African Commission for Conservation and Regional Utilization of Soils
SADC	Southern Africa Development Community
SADCMPC	Southern Africa Development Commission Migrant Pest Control
SAO	Senior Agricultural Officer
SEA	Supplemental Environmental Assessment
STO	Senior Technical Officer
TAMS	TAMS Consultants, Inc., New York, NY/Arlington, VA, USA
TO	Technical Officer
USAID/ Botswana	USAID Mission to Botswana, located in Gaborone
USAID/W	US Agency for International Development, Washington, DC
USDA	US Department of Agriculture

1.0 EXECUTIVE SUMMARY

This assessment is a supplement to the Programmatic Environmental Assessment (PEA) for Locust and Grasshopper Control in Africa and Asia. It was developed to provide particular, country-specific details in Botswana in order to allow USAID assistance in locust and grasshopper management in the event of need. It is therefore an extension of the PEA for Locust and Grasshopper Control and is, as such, an integral part of it.

The information contained in this document is intended for use by USAID/Botswana and the Botswana PPD to guide environmentally sound locust and grasshopper management in all regions of the country. Among the acridian species which threaten agriculture in Botswana are the Brown Locust (Locustana pardalina), the Red Locust (Nomadacris septemfasciata), and the African Migratory Locust (Locusta migratoria migratorioides). Localized activity of each of these species occurs annually, and some spot treatments are usually required. In recent years, however, migrating swarms have caused problems in Botswana from the north in 1993-94; breeding populations developed along the northern border of the country. Serious invasions, along with establishment of breeding populations, of Brown Locusts occurred in 1986. In 1993, a more localized outbreak, along with limited breeding populations, was restricted to the southern tip of Botswana.

The recent outbreaks were controlled by teams from the Plant Protection Division (PPD) of the Botswana Ministry of Agriculture (MOA). Control activities included survey and operations in the Caprivi Strip (with consent of the Government of Namibia). PPD has the capacity for ground-based control operations under locust population conditions which are not at emergency levels. It has a more limited response capability for outbreak emergencies of short duration or within limited areas. Some ground-based and aerial operational assistance has been available from the International Red Locust Control Organization - Central and Southern Africa (IRLCO-CSA).

Much of the discussion in this SEA will be directed towards the three locust species cited above. However, the discussions herein need not be limited to a specific pest or region of the country, provided that consideration is given to the climatic, biological, and environmental diversity of Botswana. Additional relevant information should be added to this SEA as needed, as this is a dynamic, rather than static document. As it is part of the PEA, both documents should be consulted during all planning and operational stages of implementation.

Survey and immediate treatment operations are considered foremost in preventing locust or grasshopper outbreaks. Prevention is the key to reducing crop loss and pest control

operation costs. Early season intervention requires considerably less pesticide than late season emergency operations, and therefore has less impact on the environment. Survey data are gathered by PPD when rain and wind conditions are conducive to outbreaks. Other sources of survey information are the Republic of South Africa-based Southern Africa Commission for Conservation and Utilization of Soils (SACCUS) and the regional Southern Africa Development Commission Migrant Pest Control (SADCMPC) project.

Pesticide management must be a priority in control operation programs. Because misused pesticides affect both the environment and crop production in terms of increased costs, any control program must consider possible consequences carefully. Pesticide container disposal must be conducted so as to eliminate food or water storage in used containers. In this regard, supportive legislation and regulations must be enforced to promote sound management practices.

Training should be part of any USAID assistance program. Pesticide safety and the environmental effects of pesticide use and misuse should be conveyed to PPD personnel and the general public through education and public awareness campaigns. Farmer training and Village Brigades can be an important part of management operations, and should be stressed.

The Botswana PPD should implement a laboratory analysis program to monitor pesticide formulation quality, environmental residues, and effects on non-target species and the environment. Analysis of blood cholinesterase testing in pesticide handlers and applicators is strongly recommended.

Environmental awareness is emphasized. Fragile ecological areas need to be protected from pesticides, as the impact can be both dramatic and long-lasting. Buffer zones of at least 5.0 kilometers surrounding ecologically sensitive areas should be supported in any U.S.-funded control operation. Because of the Botswana's great environmental diversity and the importance of wildlife to Botswana's ecology and economy, this document recommends that U.S.-funded assistance in l/g management promote biological control as alternatives to the use of chemical pesticides. Several strategies exist which can allow for substantial l/g control; this S&A recommends that FAO take a lead in this area, because of that organization's considerable experience with such efforts in Africa and Asia.

Monitoring of pesticide effects on non-target species and the environment should be included as an integral part of any pesticide use program. Monitoring results should be used in the planning and operational phases of future locust control programs to adjust or curtail environmentally damaging operations.

2.0 PURPOSE AND PROCEDURES

2.1 Background

With the major upsurge of the Desert Locust (Schistocerca gregaria) in Africa beginning in late 1986 and lasting into 1989, and extensive grasshopper (numerous species) outbreaks throughout the Sahel from 1986 through 1989, the U.S. government was called upon by concerned African nations to assist with technical expertise and needed materials in the management of these insects. In 1987, the Administrator of the U.S. Agency for International Development declared an emergency waiver of the agency's environmental procedures governing the provision of pesticides. The waiver permitted USAID to provide assistance for procurement and use of pesticides for l/g control without full compliance with the Agency's environmental procedures. The Administrator's waiver expired on August 15, 1989.

With the expiration of the Administrator's waiver, any subsequent USAID assistance in procurement and use of pesticides must fully comply with the Agency's environmental procedures. In 1989, a Programmatic Environmental Assessment (PEA) was completed. The PEA, and the country-specific Supplementary Environmental Assessments (SEAs) will serve as the basis for these regulatory procedures. The SEAs contain specific environmental information for each country involved, and provide guidance on environmentally sound management procedures. SEAs have been completed for most of the Sahelian countries.

Given the periodic nature of locust outbreaks, and the cyclic population fluctuations of grasshoppers, control campaigns for these insects are likely to continue indefinitely. Locusts and grasshoppers are part of the ecology of the African continent, and will readily take advantage of agricultural crops. Control measures must manage problematic insects at economically reasonable levels in regard to crop loss, rather than try to achieve extermination. In recent years, the Botswana PPD has found itself involved routinely in at least limited control of locusts and grasshoppers; and in 1993-94, intensive intervention was required against migratory swarms of all three locust species that threaten the agriculture of the country. In light of this recent trend in l/g activity, it becomes critical to both USAID/Botswana and to PPD that an SEA is in place, should assistance in l/g control be required. A goal of any U.S.-funded assistance in l/g management should be sustainability of operations by the Botswana PPD.

Because of the both periodic and cyclic abundance of locusts and grasshoppers, and their potential impact upon food supplies, it is likely that requests for USAID technical assistance, aerial

application services, commodities, equipment and/or insecticides will continue. While it is likely that most of these requests will be related to the use of chemicals for control operations, it is important that USAID take the lead in investigating and providing alternatives to chemicals which have a potential negative environmental impact. Should USAID/Botswana choose to provide chemical pesticides, the Environmental Procedures in Regulation 16 (22 CFR 216) must be followed. Along with the PEA, this document fulfills the requirements necessary to allow USAID to provide assistance to Botswana. Because locust control operations would most likely be concentrated in the northern and southwestern parts of the country, this SEA emphasizes, but does not restrict itself to, those parts of Botswana.

2.2 Drafting Procedures

USAID Environmental Procedures (22 CFR 216.3(a)(4)), describes the process to be used in preparing an Environmental Assessment. The rationale and approach for the country-specific Supplementary Environmental Assessment (SEA) are outlined in cables 89 State 258416 (12 Aug. 1989) and 89 State 275775 (28 Aug. 1989).

This draft Supplementary Environmental Assessment (SEA) for the country of Botswana was produced in October, 1994, by AID/W (AFR/DRC) contractor David Evans with assistance from Robert McColaugh, Agricultural Development Officer, and Pushkar Brambhath, Mission Engineer. Assistance in the form of transport, documents, and contacts within the Botswana government was provided by P.O.P Mosupi, of the Plant Protection Division, Ministry of Agriculture.

Interviews were held with representatives of Botswana government agencies, NGOs, other donor governments, FAO, and UNDP. Extensive field observations were made on locust breeding sites, outbreak areas, and pest management capabilities during site visits to the Chobe River floodplains and the Zambezi River basin on the northern border of the country (African Migratory Locust and Red Locust); and to the dry riverbed and upland areas of southwestern Botswana (Brown Locust).

2.3 Previous Assessments

The previous assessment concerning this subject, and the primary supportive document, is the **Programmatic Environmental Assessment for Locust and Grasshopper Control in Africa/Asia** (TAMS/CICP, 1989) (PEA). The PEA covers grasshopper and locust control operations in Africa and the Near East. This SEA is a supplement to the PEA, and should be considered an integral part

of the PEA: it concerns the country-specific environmental issues not addressed in the PEA.

Other assessments regarding locusts or grasshoppers include:

- (1) **The Africa Emergency Locust/Grasshopper Assistance Mid-term Evaluation.** (with specific-country case studies for Chad, Mali, Niger, Mauritania, and Cape Verde) (Appleby, Settle & Showler, 1989);
- (2) **Final Report on the Handling of Pesticide in Anglophone West Africa.** (Youdeowei, 1989, FAO Conference report, Accra, Ghana);
- (3) **Final Report on Pesticide Management in Francophone West Africa.** (Alomenu, 1989, Report to the FAO Conference at Accra, Ghana);
- (4) **Draft Environmental Assessment of the Tunisia Locust Control Campaign.** (Potter et al, 1988);
- (5) **Supplementary Environmental Assessments** for the countries of Burkina Faso, Cameroon, Chad, Eritrea, Ethiopia, the Gambia, Kenya, Madagascar, Mali, Mauritania, Mozambique, Niger, Senegal, Somalia, and Sudan.

These documents have been used freely in the preparation of this assessment and are often relied on without citation. Internal USAID/Botswana data are used without citation. Other relevant documents are cited in the text when supportive data are used.

In addition to the above locust-specific documents, there are other documents which concentrate on pest management and agricultural issues or environmental and biological aspects of Botswana. Of particular interest is Ministry of Finance and Development Planning: **National Development Plan 7: 1991-1997.** Agricultural production information is found in Ministry of Agriculture, Central Statistics Office: **1990 Agricultural Statistics.** FAO/UNDP (1992): **Strengthening Plant Protection. Botswana,** cited in Sect. 5.0, presents a critical analysis of the plant protection capabilities in Botswana and provides organizational and legislative recommendations. Ministry of Local Government and Lands: **Botswana National Report for the United Nations Conference on Environment and Development, 1992** summarizes environmental conditions and government environmental policies. These documents are fully cited in the Reference section 5.0, and should be consulted for further information.

2.4 Environmental Procedures.

It is USAID policy to ensure that any negative environmental consequences of an USAID-financed activity can be identified and mitigated to the fullest extent possible prior to a final funding and implementation decision. This document covers specific environmental consequences involved with chemical pesticide use, and necessary safeguards and mitigation for any future control programs. In addition, alternatives to chemical pesticide use are highly recommended when appropriate, and considered to be part of an overall integrated pest management (IPM) program.

Although Botswana does not have procedures precisely equivalent to the National Environmental Policy Act (NEPA) or USAID Environmental Procedures, it does have sets of regulations governing the substance of such programs. These are covered in the following section. USAID Environmental Regulations and Procedures are likely to be controlling for the present because they are more comprehensive and more applicable to USAID programs and projects.

2.5 Botswana Environmental Procedures.

2.5.1 Botswana Pesticide Regulations.

To facilitate proper and safe use of pesticides, regulations are necessary which cover importation of pesticides, distribution to agricultural areas, actual use of the pesticide, and disposal of unwanted pesticide and used containers. Legislation on pesticide use, management, and registration is in draft form; and approval by Parliament is expected. This proposed Pesticide Act is based on the **FAO International Code of Conduct for Distribution and Utilization of Pesticides**. Pesticide imports, distribution, quality assurance, and labeling have been virtually unregulated up to the present time, and adoption of the legislation will considerably enhance agricultural, environmental, and public health policies in Botswana. This SEA commends GOB for proceeding with potentially very effective pesticide legislation, and supports placing high priority on instituting enforcement procedures. Enforcement of pesticide legislation will require personnel who have received adequate training in pesticide use, recognition, and labeling.

A U.S. pesticide contribution to Botswana, or a U.S.-funded pesticide purchase in Botswana, will be controlled not only by applicable Botswana laws and regulations, but also by U.S. pesticide regulations and procedures, as described in the PEA. In this regard, only those pesticides listed in the PEA, or amendments thereof, are acceptable unless this SEA is amended to

cover possible environmental impact which may result from use of that particular pesticide. Pesticides used in a U.S. operation are to be used according to label instructions only. Used pesticide containers and any unwanted pesticide resulting from a U.S.-funded operation must be disposed of properly and safely. No U.S. funds shall be used to purchase, transport, or apply any pesticide that has been banned in the United States. This especially includes chlorinated hydrocarbons such as dieldrin and lindane.

2.5.2 Other Environmental Regulations in Botswana.

Responsibility for environmental protection is divided among several different Ministries in Botswana. Although the legislation appears adequate, the fact that it falls under different authorities has caused overlaps, conflicts, and difficulties in enforcement. Some laws are not strictly enforced because of a lack of institutional support and adequately trained personnel. The Government began preparation of a National Conservation Strategy (NCS) in 1985 as a mechanism to coordinate enforcement of existing laws, establish new environmental legislation and to formalize the need for presentation of Environmental Impact Assessments along with project proposals having environmental implications. The NCS Advisory Board became operational in 1992, and a task force is presently studying the most effective mechanism for implementation of the NCS: a possibility is that of NCS becoming a parastatal affiliated with the Ministry of Finance.

The organization responsible for managing Botswana's park and reserve system is the Department of Wildlife and National Parks (DWNP) in the Ministry of Commerce and Industry. A major role of DWNP is that of coordinating all matters concerning wildlife and national parks. DWNP's objectives include conservation and management of the natural environments of Botswana and their flora and fauna. Parks and preserves are protected under the Wildlife Conservation and National Parks Act (1992). Parks and preserves occupy 17% of Botswana's total land area and Wildlife Management Areas occupy an additional 23%.

Environmental legislation which includes components directly related to insect pest management are the Plant Diseases and Pests Act (plant quarantine and import restriction), the Public Health Act (protection of foodstuffs, mosquito control. The Locusts Act provides for the destruction of locusts and obliges any individual whose land is invaded by locusts to report to the nearest authority.

Other legislation concerning the environment includes the Atmospheric Pollution (Prevention) Act, the Forest (Reserve) Act,

the Herbage Preservation (Prevention of Fires) Act, the Borehole Act, the Aquatic Weeds Control (Importation) Act, and the Fish Protection Act.

Any USAID/Botswana-funded programs involving pesticide use for locust or grasshopper control should follow Botswana regulations concerning the protection of designated areas. In that regard, this SEA supports the GOB commitment to protect the natural environment, and adopts any conditions to be mandated by GOB limiting the use of pesticides, and also concurs in any designated zones that are protected from pesticide use.

3.0 PROJECT DESCRIPTION

3.1 Botswana Environmental Profile

Botswana lies on the Tropic of Capricorn in the center of the Southern African Plateau. The mean altitude above sea level is 1000 m and the land area is 582,000 km² -- about the size of Texas. It is a landlocked country, bordered by Zimbabwe, the Republic of South Africa, Namibia, and Zambia. The Caprivi Strip of Namibia extends across the northern border of Botswana (Fig. 1). The topography is flat, with gentle undulations and rocky outcroppings. The Okavango River drains inland from Angola in the northwest to form the Okavango Delta. A large area of calcrete plains surrounds the Makgadikgadi pans in the central northeast. The Kgalagadi (Kalahari) Desert accounts for more than two-thirds of Botswana's land area. The sand cover is up to 120 m deep, supporting scrub brush and grasses, with an almost complete absence of surface water. In the eastern part of the country, adjacent to the Limpopo drainage system, the land rises above 1200 m. This eastern region has a somewhat less harsh climate and more fertile soils that are found elsewhere; most of the population is concentrated in this region.

Because it is situated close to the subtropical high pressure belt of the southern hemisphere, the country is largely arid or semi-arid. Mean rainfall ranges from over 650 mm in the extreme northeast to less than 250 mm in the extreme southwest. Almost all rainfall occurs during the summer, from October to April. Most rainfall occurs as localized showers and thunderstorms, and its incidence is highly variable (Fig. 2). Average daily maximum temperatures range from 72°F in July to 91°F in January. Average daily minimum temperatures range from 41°F in July to 68°F in January. Vegetation types are closely correlated with climate (Fig. 3). Away from the bush swampland of the Okavango Delta, the vegetation has to withstand long dry periods each season. Higher rainfall in the northern Chobe District supports forest and dense bush. More than half the country supports scrub and tree savanna with mopane trees (Colophospermum mopane) and Acacia spp. dominating in the northeast. Less than 5% of the land area is devoted to arable agriculture; much more of Botswana's land is used for beef production. Overgrazing has caused deterioration of rangeland in some areas.

With a population of just over 1,000,000, Botswana has one of the world's lowest average population densities. It is high, however, in view of the extremely fragile natural resource base. The main features of population distribution are a concentration in eastern Botswana, where land and water resources are best; a

Figure 1. Republic of Botswana

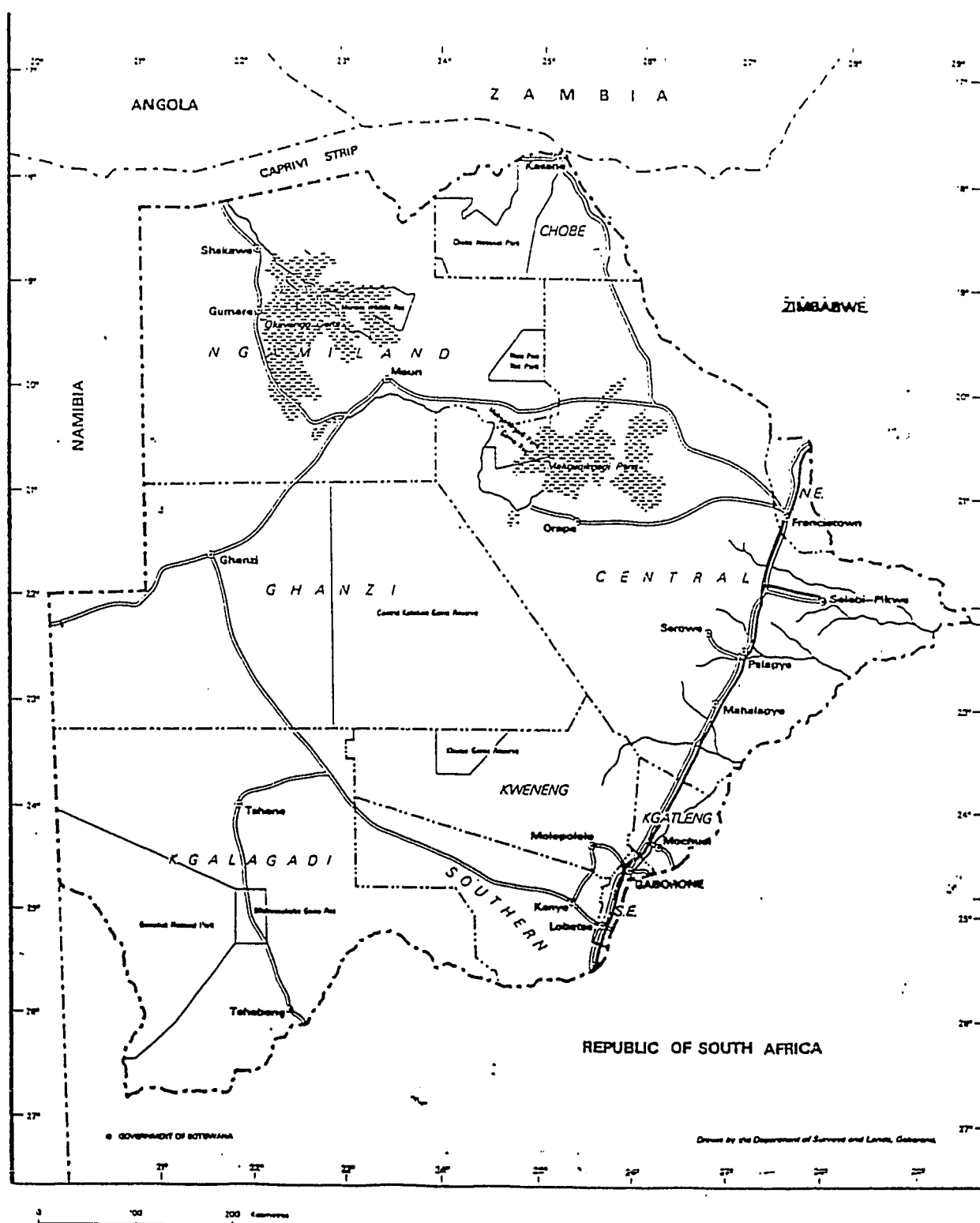
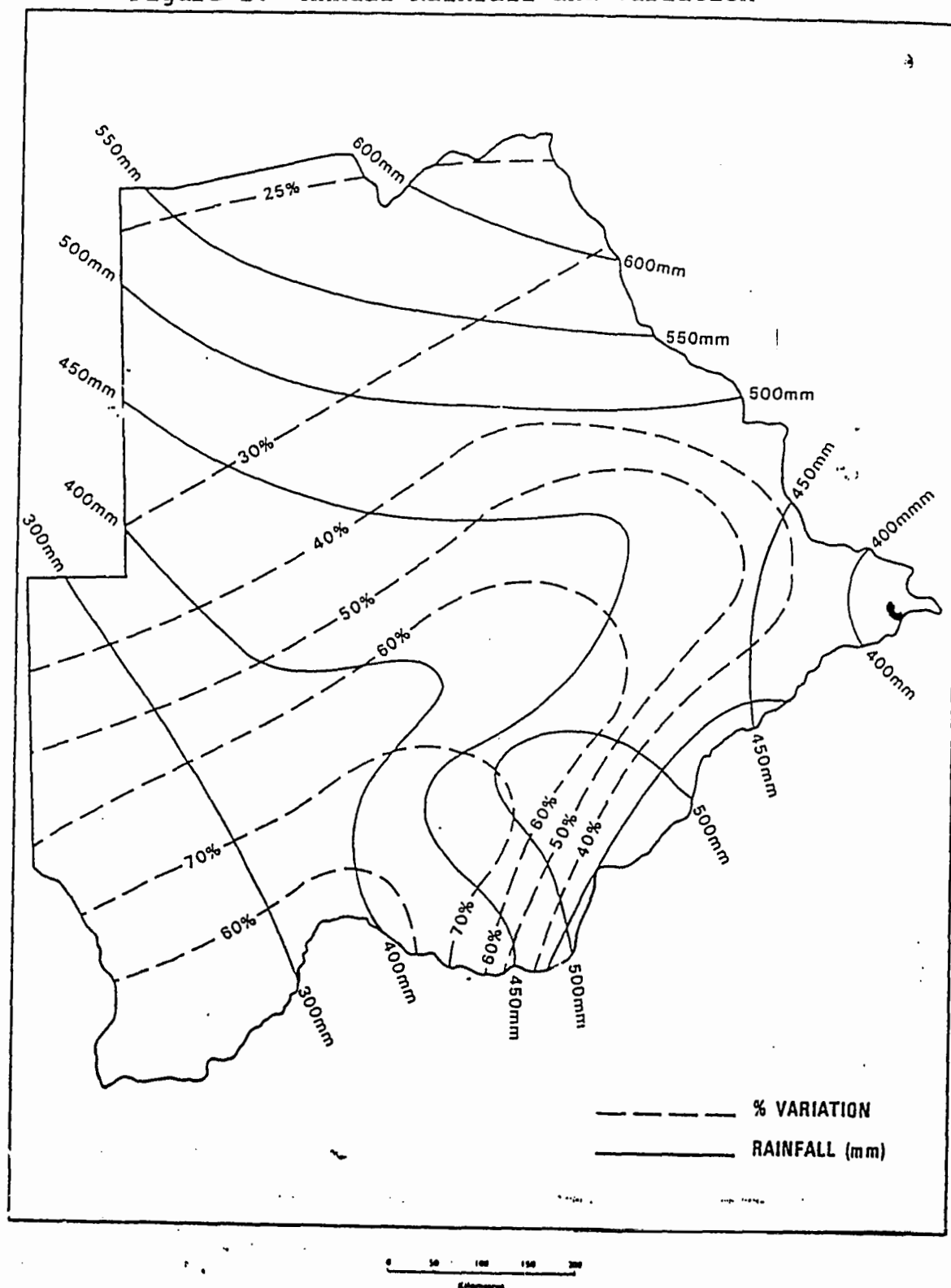


Figure 2. Annual Rainfall and Variation



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predominantly rural population, but with rapidly growing urban centers; and declining seasonal movement between villages, arable lands, and cattle posts.

3.2 Agricultural Resources

Botswana's agricultural economy is highly dependent on beef production. The cattle industry is a major contributor to exports, and beef export earnings more than cover the cost of basic cereal imports. About 60% of the land is suitable for livestock grazing, but numbers of animals are above carrying capacity of the land in some rangeland areas. Commercial farms cover about 8% of the land area, but only represent less than 2% of the total number of farms. They specialize in livestock: about 90% produce cattle, but only 30% grow crops. 20,700 ha (of 24,400 ha allocated) have been planted in sorghum at Mpandamatenga, in the Chobe District government-subsidized farms, and represent an extensive crop area which is vulnerable to locust and grasshopper outbreaks.

Traditional farms cover a much larger portion of Botswana's total land area, with over 80% of the population rural and dependent on agriculture. Two thirds of traditional farmers practice mixed farming. In 1988, they produced 82% of all cattle, 97% of goats and 85% of sheep. They produced 73% of all food grains and pulses. Most significant crops grown are (in order of 1990 production) sorghum, maize, beans/pulses, and millet (Fig. 4).

Crop production fluctuates widely and has been affected by droughts in the last few years (Fig. 5). With such great dependence of the population on agricultural production in a moisture-stressed environment, the agricultural economy at this point is one which is highly vulnerable to additional perturbations, such as insect pest outbreaks or invasion by locusts.

3.3 Locusts and Grasshoppers

The insects considered in this document are locusts and grasshoppers. The three locust pest species of greatest importance in Botswana are the African Migratory Locust (Locusta migratoria), the Red Locust (Nomadacris septemfasciata), and the Brown Locust (Locustana pardalina). Swarms of all three species have caused serious damage in the country, and may even occur concurrently. In addition, there are a number of grasshopper species which can become pests depending on environmental

Figure 4. Crop Areas Planted, 1984-1990

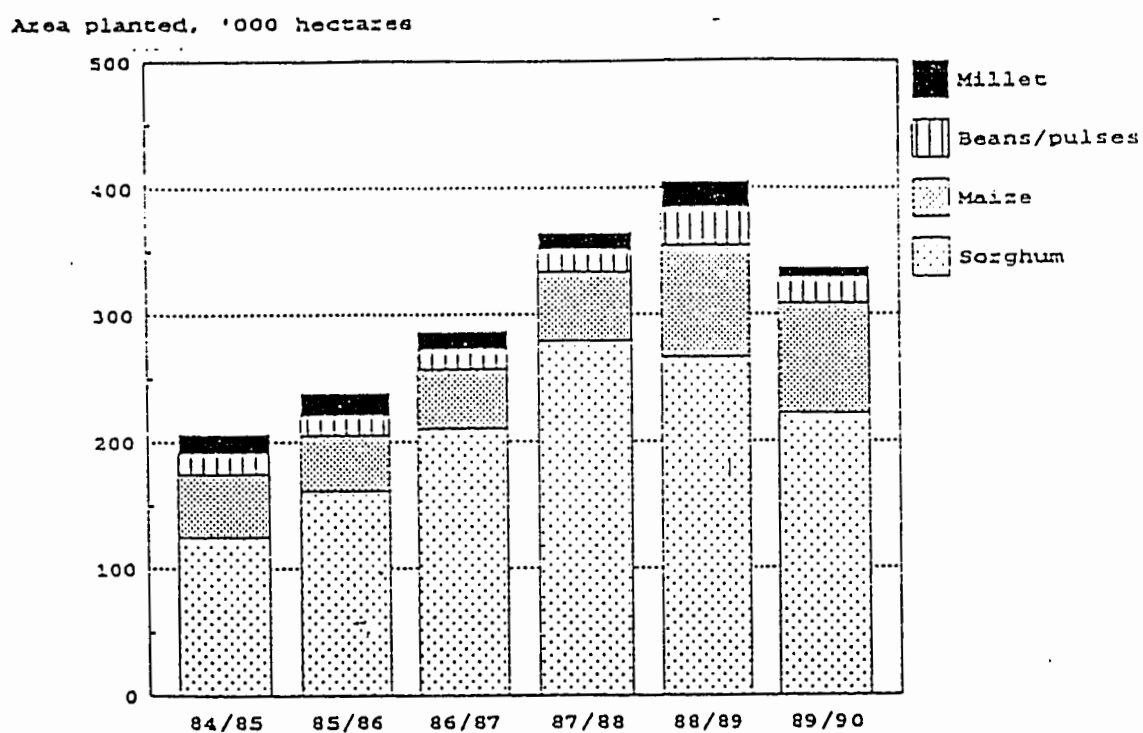
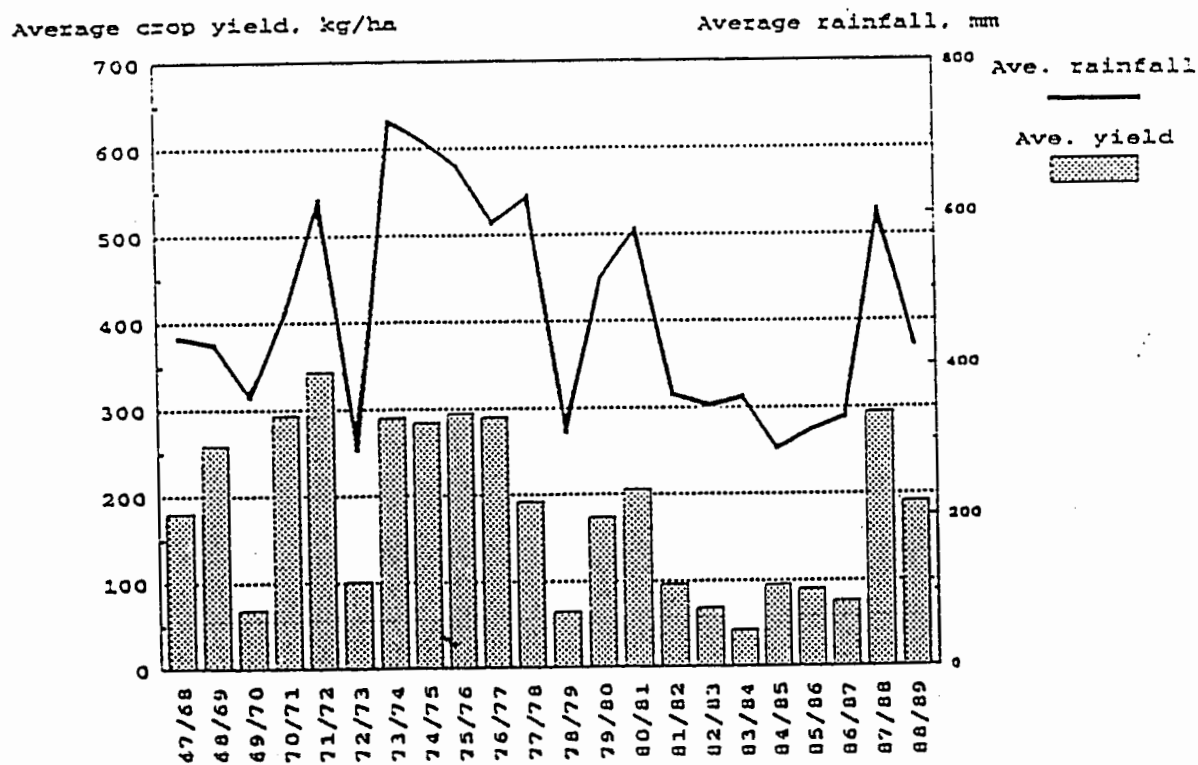


Figure 5. Rainfall and Crop Production, 1967-1989



Source: Ministry of Agriculture.

conditions. The most damaging is the Elegant Grasshopper (Zonocerus elegans), which can occur in population concentrations throughout the entire agricultural region. Seven other grasshopper species are pests of moderate to serious importance in Botswana.

The three locust species are characterized by migrating gregarious swarms, yet they are ecologically distinct:

Brown Locusts are desert breeders. Swarms affecting Botswana originate in the Karoo region of South Africa and move north. In years that a reproducing population reaches Botswana, breeding occurs in the dry beds of the Malopo and Nosop Rivers on the southern border of the country, with some breeding in grass and scrub desert uplands of Kgalagadi and Kweneng Districts (Fig. 6). Swarms from these breeding sites can then move into agricultural regions from the south. The season of activity is November-April.

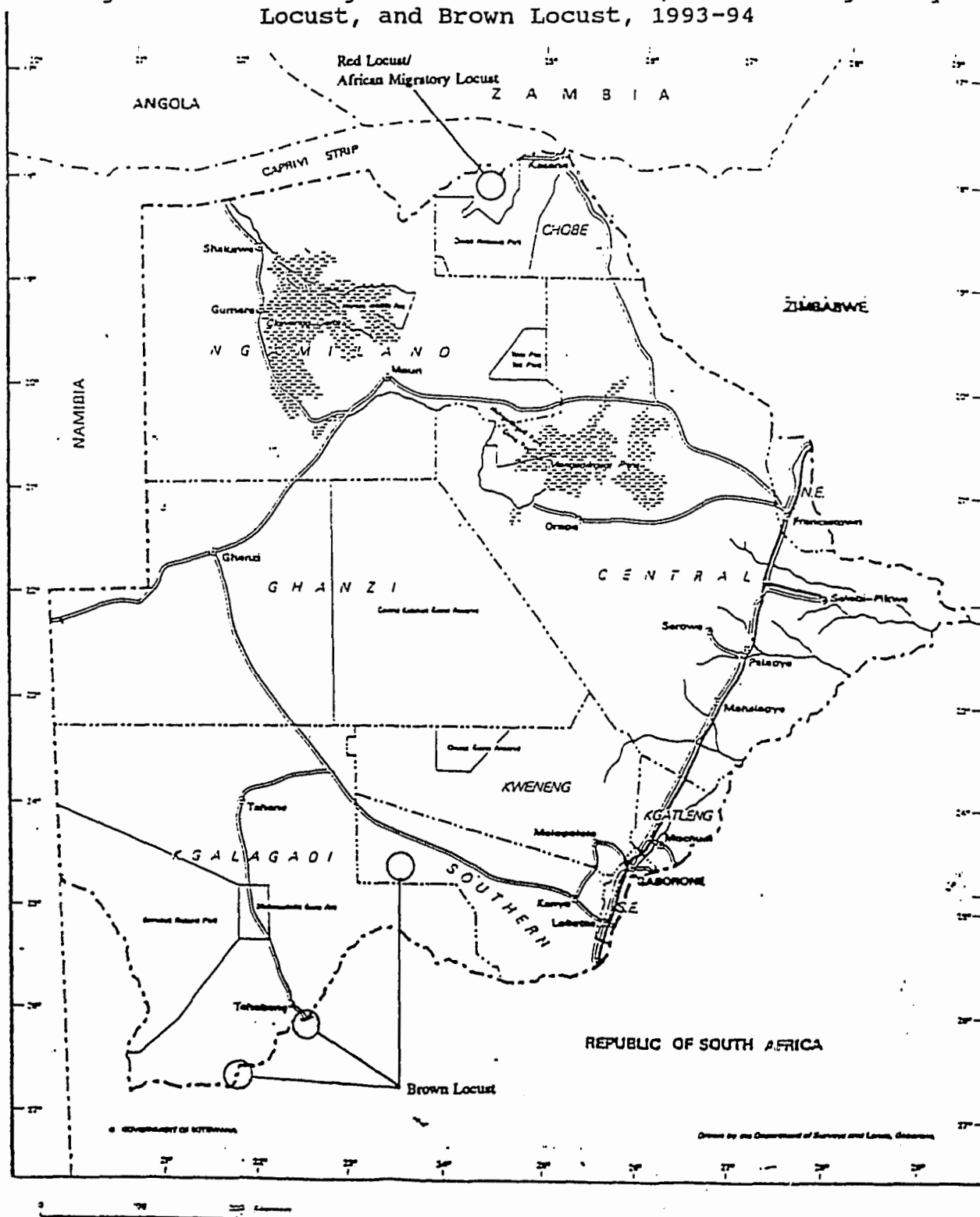
Red Locusts breed in wetlands and floodplains of the Linyata, Chobe, and Lyambezi Rivers on the northern border of the country, extending along the Caprivi Strip of Namibia (Fig. 6). Red Locust swarms move into Botswana from the north, continuing in south to southwesterly movement, depending on the winds. The season of activity is January-March.

African Migratory Locusts breed in semi-desert conditions and are less geographically restricted by suitable breeding areas than the Brown and Red Locusts. Breeding occurs in both floodplains and uplands of the Chobe region (geographically overlapping the Red Locust breeding area) (Fig. 6) as well as in Central District to the south. This lack of limitation on breeding areas can allow swarms access to all regions of the country. The season of activity is October-April.

Some localized activity of all three locust species occurs every year, and spot treatments are usually required. Serious wide-ranging infestations are more sporadic. Grasshoppers will be found in Botswana at varying levels of infestation every year. PPD field personnel can make decisions on spot treatment of locusts; grasshopper treatment decisions are made after survey by personnel from PPD Headquarters in Gaborone.

Areas which are vulnerable to l/g attack are also threatened by other pests of concern to growers and PPD. Rodents are especially destructive in the Mpandamatenga farm area of Chobe District, quelea birds cause damage to grain crops in the Francistown region of Central District, corn cricket has been serious in Kgalagadi and Kweneng Districts, and African armyworm and American bollworm reach outbreak populations irregularly.

Figure 6. Breeding Areas of Red Locust, African Migratory Locust, and Brown Locust, 1993-94



3.4 Locust Management - Overview

3.4.1 Past Locust Campaigns

The three locust species discussed in this document are normal parts of the biological system in Southern Africa. Periodic upsurges and migrations occurred even before the introduction of extensive agriculture. With the introduction of agriculture, however, these insects, along with other species that are considered "pests," could readily take advantage of crop lands in the path of the migrations.

African Migratory Locust swarms invaded from the Caprivi Strip in 1993-94. Fifteen swarms moved into the country between September and December. After a hiatus due to maturation of hoppers nine more swarms entered after the beginning of January. The area affected ranged from the Chobe District to western Ngamiland. There was also an outbreak of Red Locusts in Chobe District between January and March of 1994; as populations of both species entered from the north, Botswana would be greatly benefited by effective locust control by the Namibian CPS operating in the Caprivi Strip. Appendix C summarizes the 1993-94 control program in the Chobe District against breeding populations and invading swarms of both the Red Locust and the African Migratory Locust.

There was a serious outbreak of Brown Locusts in 1986, during which invasion and breeding extended as far north as the northern border of Ghanzi District. A more localized outbreak occurred in the southern tip of the country in 1993. Both outbreaks emanated from the Republic of South Africa; Botswana is also dependent on effective locust control by the South Africa CPS.

The recent outbreaks were controlled by PPD teams operating the affected areas, including (with consent of the Government of Namibia) survey and operations in the Caprivi Strip. During the locust management programs, equipment was kept at Regional and District Agricultural Offices in the areas of the country affected. Chemicals for the campaign were not stored in the field for long periods, but were distributed from PPD Headquarters in Gaborone in operational quantities. Quantities remaining at the end of the campaign were returned to Gaborone.

Limited operational assistance has been available from the International Red Locust Control Organization - Central and Southern Africa (IRLCO-CSA). IRLCO-CSA is an Africa Development Bank-funded regional locust control organization; there are nine member countries: Botswana, Kenya, Malawi, Mozambique, Swaziland,

Tanzania, Uganda, Zambia, and Zimbabwe. Two aircraft and a helicopter are available, as is survey and forecasting information. In past aerial control campaigns against Red Locusts and African Migratory Locusts, aircraft have been based at Palapye (Central District) and at Kasane (Chobe District). Aircraft used in Brown Locust control have been based at Jwaneng (Kweneng District).

Two other major sources of survey and forecasting information are used by PPD, along with IRLCO-CSA reports. The RSA-based Southern African Commission for Conservation and Regional Utilization of Soils (SARCCUS) and the regional Southern Africa Development Commission Migrant Pest Control (SADCMPC) project both provide PPD with notification of migrant pest population buildup and movement. PPD receives weather data from the Central Forecasting Office of Botswana Meteorological Services (BMS) and begins its own survey activity in Botswana at times when rain or wind conditions are conducive to locust outbreaks. BMS data are also used to track swarm movements after outbreaks have occurred.

3.4.2 Crop Loss Assessment

In considering locust damage to agriculture, there is a basic assumption that these insects cause significant crop loss and therefore must be controlled. The amount of crop yield that is lost due to an infestation of these insects is a particularly important parameter, and should be determined as soon as possible to assist in the decision as to both the level of funding needed, and the amount of pesticide to be discharged into the environment. Crop loss information is therefore needed to guide both the Botswana PPD and USAID (as well as other donors) in the level of response which may be needed. Once infestation levels can be related to yield loss, management operations can be more realistic in determining the level of effort needed.

In addition to national aggregate crop losses, consideration also needs to be given to the social and economic costs of grain distribution even when losses to individual farmers or villages may be small. Even if the overall crop loss is low, some localized areas may experience high losses. Costs of grain transport over long distances may be more prohibitively expensive than those of a locust/grasshopper control program. Losses in grasslands are more difficult to assess than in crop lands, because impacts are on wandering grazing animals, and thus somewhat indirect.

Crop losses can vary geographically, with extreme damage occurring near areas which seem untouched. Regional information on crop productivity, l/g infestation levels, and efficacy of control efforts needs to be compiled and analyzed over a period

of years in order to obtain more precise estimates of locust management program cost effectiveness. This SEA strongly urges that such data collection and analysis be undertaken.

3.4.3 Predictability/Breadth of Operations

Locust infestations are difficult to predict in advance. Rainfall distribution is influential, but locusts often occur in patterns not easily related to any obvious environmental determinant. Because of this unpredictability, surveillance is essential for designing tactics to maintain low locust populations and prevent outbreaks. As rainfall and the vegetation that follows it are important factors, remote sensing techniques and satellite-derived Greenness Maps may be useful as additional guidance to supplement field surveillance.

Field survey is essential in locust management programs, and must be given high priority by both the PPD and assisting donors. Included in the survey program must be a sound knowledge of pest biology and an understanding of the impact of environmental conditions. Survey results need to be relayed to PPD in Gaborone in a timely manner, in order to allow administrators time to direct logistical operations and obtain needed materials.

Although some survey and operational assistance may be available from IRLCO-CSA, the organization responsible for major control activities is the Botswana PPD. Although this organization has some of the expertise needed for a responsible management campaign, additional training programs should be considered. The PPD is responsible for planning, survey, operational control and campaign assessment, and personnel must be trained to use pesticides in a safe and environmentally sound manner.

In instances of a locust emergency, PPD should be encouraged to work closely with IRLCO-CSA and the donor community to insure that repetition of unneeded material or pesticide donations and excess stock buildup do not occur.

3.4.4 Level of Infestation

Grasshoppers and locusts vary over a range of population levels in their natural habitat, depending upon rainfall and other environmental conditions. A migrating infestation of locusts, depending upon wind conditions and movement patterns, can have a significant impact on agriculture. For grasshoppers, crop infestation levels depend upon the numeric density and life stage of the insect. In Botswana, grasshoppers may be a problem in some regions every year. Locusts, however, are widely

periodic and can fluctuate greatly over time periods of five to ten years, if not longer.

For management planning purposes, impact on ultimate crop yield has been divided into four infestation levels. Note that these levels are quantified in relation to the intervention threshold level. The intervention threshold (also called economic threshold) is very specific to the crop, life stage of crop, insect species, and insect life stage. This concept is discussed in more detail in section 3.5.5 of this document.

Level 0 describes a "normal" density of locusts or grasshoppers. In this regard, locust and grasshopper density levels will be below the intervention threshold level for a given species. Crop losses from this level of infestation are minor and localized. The PPD is capable of carrying out any needed treatment programs without donor assistance.

Level I describes a situation with locust or grasshopper populations at levels which will require additional donor assistance to avoid crop loss. In this case, pest densities will be at or slightly above intervention threshold levels. The PPD may need assistance to cover additional costs, including materials and equipment needed to reduce population levels.

Level II describes high locust or grasshopper densities with large numbers in both crops and pasture lands. Here, l/g densities will exceed the intervention threshold level. The capacity for PPD management will likely be exceeded. Significant crop loss is probable without additional donor assistance and intervention.

Level III describes a situation involving very high locust or grasshopper populations extending over a large area. Again, densities exceed the intervention threshold. This situation will require considerable donor assistance and intervention to avoid l/g outbreaks and substantial crop loss.

Because of the complex effects of crop loss, investments by donors at each of the four intervention levels may be justified. At each level, assistance which builds sustainable infrastructure would be most appropriate.

3.4.5 Thresholds for USAID Assistance

The PPD is expected to maintain an ongoing insect management program during periods of normal pest levels. This program should include efforts to reduce human health risk, protect environmentally sensitive habitats, and minimize pesticide use through use of cultural, biological and traditional means of control. In decisions on assistance to the PPD for locust or

grasshopper management activities, USAID/Botswana will examine both the pest situation and the capabilities of the PPD. Decisions will be made in such a way as to minimize the amount of pesticide used.

If USAID/Botswana does choose to participate in an assistance program, it is important that support be coordinated with other donors and the GOB to achieve a reasonable and balanced program. Assistance for such a program should emphasize the principles of Integrated Pest Management (IPM) (as discussed in section 3.5.5), in that all available management resources should be considered. While probable crop loss will be a criterion for USAID/Botswana involvement in control efforts, sustainable infrastructure development and cost/benefit ratio will also be considered. Participation by USAID/Botswana in emergency operations will be carefully tempered with an examination of what long-term benefits will be achieved in addition to an insect population decrease. Because use of pesticides in Botswana has been increasing over the last few years, USAID/Botswana will assist primarily with a program emphasizing effective survey procedures and use of non-chemical control methods.

The level of USAID/Botswana participation in a l/g management program should not only be related to the extent and severity of the problem, but also to the extent such assistance will yield greater sustainability of PPD programs. The actual level of intervention assistance will depend upon a number of variables, including insect density, crop conditions, PPD response capability, environmental conditions, and the potential for a major outbreak. It is highly recommended that USAID/Botswana request technical assistance from AID/W in making these determinations.

Prior to implementation of l/g assistance, a thorough analysis of needs is necessary. In evaluating areas of assistance, USAID/Botswana should be responsive not only to requests of the GOB, but must further ascertain what materials the PPD and IRLCO-CSA already have, and what other donor-supported programs are planned or implemented. Supplying the PPD with an overburden of pesticides, unneeded materials, or poorly planned training will not assist in managing locusts or grasshoppers. In addition, an independent verification of pest identity, density, and potential impact should be made by a qualified technician prior to fund committal and allocation. In this latter regard, USAID/Botswana might request assistance from AID/W or IRLCO-CSA.

3.4.6 Disaster Level of USAID Participation

Should a substantial and extensive locust or grasshopper outbreak occur in Botswana, a large scale operation may be needed as a last resort to protect crops and reduce pest population levels. At such a level of intervention, risks to humans and the environment will be high, but the alternative of substantial crop loss may make intervention unavoidable.

In a situation calling for large-scale intervention, all possible safeguards must be instituted, with control operational decisions built on the following hierarchy: 1) crop protection, 2) environmental protection, and 3) pest population reduction. This ordering places the highest priority on crop protection, and the lowest on reducing pest populations (where the focus is on future generations of a pest species, population reduction of the present generation has not proven effective).

During large-scale operations, there is likely to be an increase in accidents, pesticide overuse, and application of incorrect formulations. The phenomenon is due primarily to the much greater use of pesticides and the pressure of panic treatments at these times. The most important function of the GOB under these conditions is to institute greater local control (for example, use of Village Brigades), and to communicate effectively with the affected population. GOB will need to describe the necessity of the emergency measures, and ensure to the extent possible the safety of the population and the environment. Operations at a local level, accompanied by appropriate training in pesticide use and safety, is greatly preferred to massive treatments by large aircraft.

The position of USAID/Botswana is to support the judicious use of such chemicals for the control of food crop-threatening pests. The first line of defense must be field survey work to monitor the population level of a particular pest. Proper monitoring will generally allow sufficient time to plan a strategy of control. Survey operations will also alert officials should pests be breeding at a faster rate than expected, or if a significant migration has occurred. The second line of defense is spot treatment via ground applications. This strategy involves personnel-intensive measures to directly attack sites of the infestation at early life cycle stages of the insect. Aerial application is considered a last resort. This control measure is used when all others have proved ineffective or when the magnitude of the threat exceeds the response capacity of PPD.

3.5 Locust Management - Operations

3.5.1 Plant Protection Division

Crop protection responsibility falls within the PPD, which is structurally within the Department of Crop Production and Forestry of the GOB Ministry of Agriculture (MOA). Pesticide recommendations are made by the PPD, with guidelines for control techniques patterned after those for RSA. They may not be the most effective in light of differences in agricultural and control practices between the two countries. PPD is capable of carrying out insect management and crop protection activities when locust or grasshopper population levels are low (levels 0 or 1, section 3.4.4). It may be appropriate to provide assistance programs to the PPD at this level, particularly in the form of training, the goals of any such assistance being to increase sustainability of the PPD infrastructure. Although action plans may be developed annually by PPD, material and equipment allocations are below those needed to control substantial numbers of swarming locusts. With vigilant survey and management programs, locusts and grasshoppers can be maintained at low population levels.

Active survey and early season management can save valuable funds and resources over the long-term, compared with costs of short-term emergency operations. IRLCO-CSA, SADCMPC, and SACCUS been critical sources of survey information and early intervention in this regard. However, additional donor assistance may be required if high infestation l/g levels exceed the capacity of the PPD. Concerning U.S.-funded assistance involving pesticides, the information, recommendations, and regulations discussed in this SEA and the PEA must be observed and reckoned with in project design and implementation.

Ideally, by developing a strong base of trained personnel and a well-maintained fleet of vehicles and equipment, the PPD will be able to hold impending grasshopper outbreaks, and invading locust swarms to a minimum. This will result in considerably less pesticide being used than if these pests are allowed to reach high population levels. In this regard, it is especially important to involve villagers and farmers living in invasion areas in early season control endeavors. These types of efforts, combined with improved legislation and regulations, will greatly lessen potential negative environmental effects of pesticide use. Any assistance USAID can offer to build such an institution, with full participation and involvement of the Botswana PPD, will be a far more effective investment than the immense amounts which have been spent on past emergency operations (with little effect on sustainable infrastructure).

3.5.2 Survey and Control Preparations

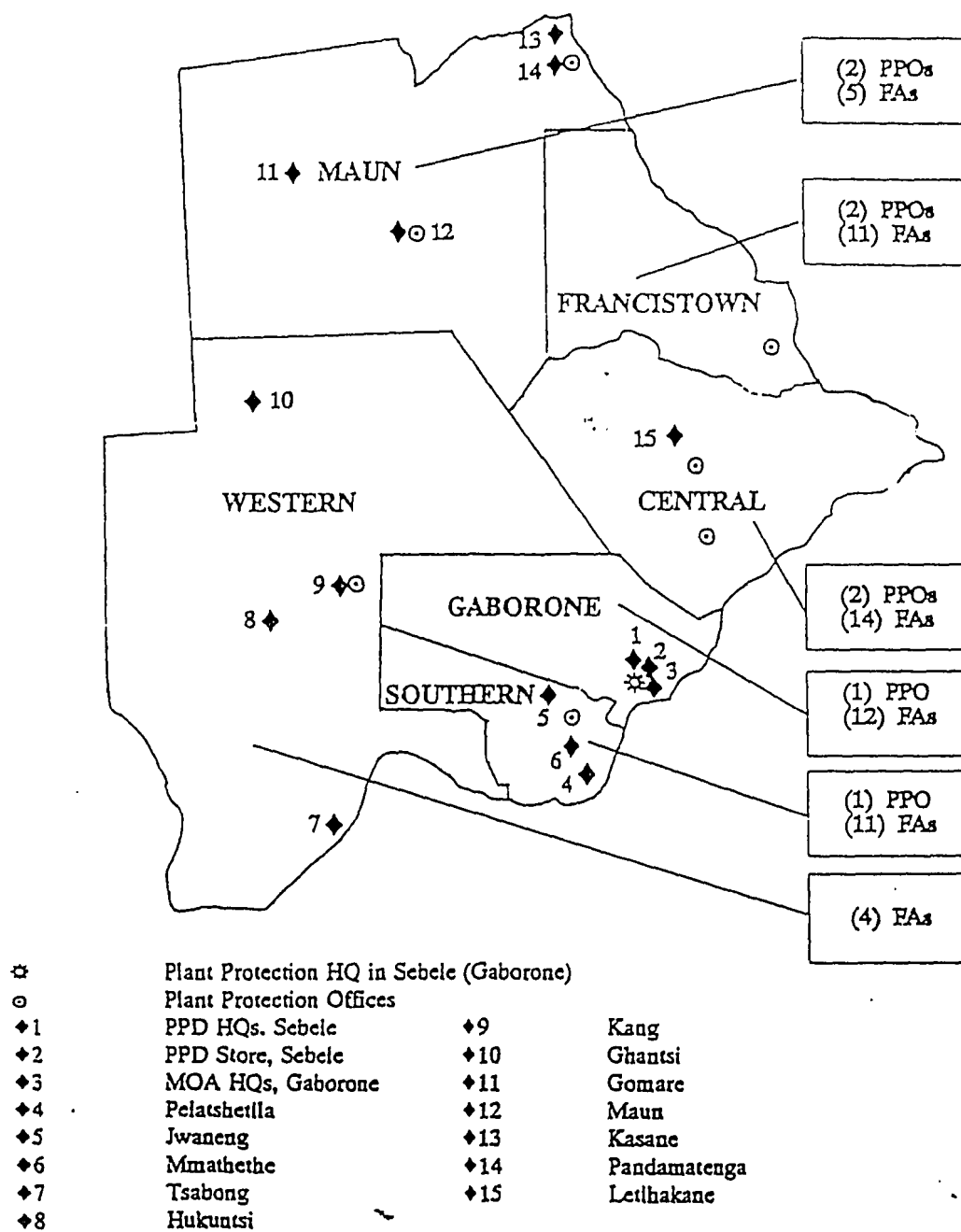
In order to keep locust and grasshopper population numbers below levels where crop loss is imminent, and reduce the environmental impact of pesticide use, it is important to survey early in the season, and to implement control activities immediately. Trained personnel, and equipment in full working order are required to do this. The main elements to be included in locust or grasshopper survey programs are:

- Full knowledge of the physical and temporal distribution of the pest species.
- Monitoring of environmental conditions and changes which might lead to increased numbers of pest species. This will require an adequate knowledge of pest species biology, the status of environmental conditions, and how these conditions can be augmenting or limiting factors.
- A vulnerability assessment in terms of crops threatened by the pest species, including relative importance of crops, and the crop stage of development, and an understanding of the vulnerability of the human population likely to be affected.
- The availability of pest management support resources to be mobilized for control: pesticides, application equipment, as well as logistical and technical support.

Survey and monitoring personnel in Botswana include PPD staff, other government workers, and local farmers. Each of 6 Agricultural Regions has one or two Regional Agricultural Offices staffed with a Plant Protection Officer and several field assistants (Fig. 7). Agricultural Regions are further subdivided into Agricultural Districts, each with a District Agricultural Office staffed with a District Officer and field assistants. Most offices are linked with a radio and telephone/FAX network, but a few, e.g., the Western District Office in Kang, do not have adequate communications facilities. Personnel in the Regional and District Offices act as the monitoring and control team for that region or district. Basic stocks of application equipment, limited amounts of chemicals for spot treatments, and protective gear are kept at District Offices. The Regional Officers are responsible for monitoring insect populations and reporting to PPD in Gaborone. Each District within a Region is divided into a number of Extension Areas, each staffed by an Agricultural Demonstrator (a total of 283 in 1991). Monitoring is done at this level, as well. Personnel in the Extension Areas are regarded as the "frontline staff," who provide training on pesticide use and safety to the farmer.

Prior to main periods of vulnerability (Sept.-Oct.), PPD should continue to ensure that District Offices in the north of Botswana are equipped and prepared to face a low level (level 0 in section 3.4.4) of l/g management. Adequate preparation would include: a working radio system, operating vehicles and application equipment, protective clothing and safety equipment that are clean and ready to use, and the needed amount of pesticides carefully stored and ready for use.

Figure 7. Agricultural Regions and PPD Offices



PPOs - Plant Protection Officers

FAs - Field Assistants

BEST AVAILABLE DOCUMENT

3.5.3 Village Brigades

Farmers can play a major role in a control campaign -- reporting population levels to actively protecting crops from nymphal infestations. With chemical control, farmer and village training programs are required. Both USAID and FAO have used the Village Brigade technique since 1987 in areas of Africa where locust or grasshopper infestations are endemic. Although PPD has relied primarily on its own personnel and that of other MOA departments seconded to them for emergency situations, the technique may be applicable to the situation in Botswana for locusts as well as other insect pests.

Each Village Brigade typically includes 10 interested and enthusiastic villagers. Participants receive 3 days of intensive training (covering identification and biology of both local pest and beneficial insect species, fundamentals of good survey techniques, and safe handling and use of pesticides); and are then given a small quantity of pesticide, a set of protective clothing, and necessary application equipment. Village Brigade members are responsible for locust or grasshopper control at the village level and are supported by the PPD.

There are limitations to the technique, however: it can lead to the assumption by affected populations that all intervention will be pesticide-based, and it can become an costly operation which requires continuing subsidization.

Support by the PPD is essential for a Village Brigade. Once a Brigade is formed, members must receive needed materials and technical support within a reasonable time frame in order to achieve crop protection. While a trained group may in theory be able to creatively defend crops against pests without resources; in reality, they will lose both enthusiasm and expertise without support.

3.5.4 Ground and Aerial Operations

Use of spray aircraft should be considered a last resort in a U.S.-funded locust or grasshopper management program. With an attentive survey program, combined with rapid deployment ground pesticide application teams, it is possible to conduct an effective management campaign without spray aircraft. USAID fully supports this concept, and the needed training programs for survey and ground teams. In addition to the basics of survey techniques, pesticide safety, and application; such training must encompass a through background knowledge of pest species that require control.

While aircraft can be effective management tools, and may be justifiably needed during locust or grasshopper outbreaks, they

should be used with caution. This is because: 1) aircraft carry and spray larger quantities of pesticide than ground equipment, and therefore are more likely to have an environmental impact; 2) they are expensive to run and maintain, and are unlikely to be sustainable without a high level of outside input; 3) assumed use or support by donors could result in less attention by the PPD to maintenance of an effective survey and ground control system.

The Botswana PPD will have access to one fixed-wing twin engine aircraft (Islander Turbo) which is presently on order, and can request assistance from IRLCO-CSA. Aircraft from IRLCO-CSA are often in demand for control operations over a wide range of southern Africa, and may be difficult to have on site at the appropriate time. PPD has made some attempts at pest management using privately hired aircraft; these have been unsatisfactory because of great expense and lack of pilots with experience in pest management operations.

Aerial control operations for locusts have produced the following generalizations:

- large infested areas can be treated in a short time;
- inaccessible areas are more easily treated;
- aircraft logistical support is expensive, and large amounts of pesticides are required;
- pesticide drift is difficult to control;
- landing strips for fixed-wing aircraft require frequent and expensive maintenance.

In light of the limitations concerning aerial control operations, it is good policy to use preventive ground control operations whenever possible. The components of ground operations are:

- training and equipping farmers and Village Brigades;
- early season surveys;
- weather monitoring;
- increased survey and ground application teams.

PPD has a regionally-distributed fleet of operational vehicles available for a locust control program (Appendix D), and 61 Micronair AU 7000 sprayers which can be mounted. Vehicle maintenance and spare parts has not been a serious problem. Standard and motorized backpack sprayers are in good supply, although spare parts for the latter can be difficult to obtain. Adequate supplies of applicator safety gear--protective clothing, gloves, respirators, boots, and goggles--are on hand.

3.5.5 Integrated Pest Management - IPM.

Integrated Pest Management uses all available control methods to achieve the most economically and environmentally sound management program. It is considered to be the preferred approach to pest control. IPM is not an alternative to chemical pesticide use; instead it is an integration of methods which may reduce use of pesticides by employing them more judiciously. Determination of intervention thresholds, correct timing of sprays based on pest population dynamics, and use of non-chemical control agents are among examples of modern and prudent pest management methods.

IPM can decrease pest losses, lower pesticide use, and reduce overall operation costs, while increasing crop yield and stability. Successful IPM programs have been developed for a variety of pests on various crops. Specifics of an IPM program will depend on the crop, cropping system, pest complex, economic values, social conditions, availability of personnel, and other factors and constraints. The following steps illustrate the development of an IPM program.

Step 1: Identify the Major Pests, and Establish Intervention Thresholds.

Dozens of potentially harmful species may infest a crop. However, only a few pest species cause substantial crop loss. The pests which recur at intolerable levels on a regular basis are known as primary pests, and are the focus of IPM programs.

The criterion that determines whether taking action to control a harmful species is profitable is called the intervention threshold (or economic injury level). The intervention threshold is that point above which control actions should be taken, and below which no actions are necessary. The economic injury level may be expressed in different ways depending upon the crop and the pest. Examples of injury level indicators could be:

- Numbers of insects per plant.
- Percentage of fruit damaged by a given pest.
- Numbers of weeds per square meter.

Several factors will influence the intervention threshold for a specific pest: crop variety and stage of development, value of the crop, presence of natural enemies, cost of control measures, as well as external costs to health and the environment. The intervention threshold depends on the relationship between pest intensity and yield loss, and the economics of reducing the damage. It will therefore change as these variables change. The intervention threshold developed in

one area will not likely be appropriate for use in a different area.

Research is needed to determine the initial intervention threshold. This threshold level must be thoroughly tested and verified under actual field conditions. The level can be refined as more information becomes available, and as it is used in the field.

Step 2: Select the Best Mix of Control Techniques.

All pest management methods and practices should be considered for an IPM program. First consideration should be given to use of preventive measures:

- Resistant crop varieties.
- Biological control (conservation or augmentation of natural enemies already present or introduced)
- Cultural control (cultivation, crop rotation, use of pest-free seed and planting stock, fertilizer management, and intercropping)

Farmers will likely already be using one or more of these preventive measures. It is therefore important to talk to the farmers before determining which measures are needed.

Pesticides should be used only if no practical, effective, and economic nonchemical control methods are available. Once the pesticide has been carefully chosen, it should be applied only to keep the pest below the intervention threshold. Pesticides will impact other organisms besides the pest, and may cause harm to humans, livestock, honey bees, natural enemies, and the natural environment.

Step 3: Monitor the Fields Regularly.

The growth of pest populations usually is related closely to the stage of crop growth and weather conditions. However, it is difficult to predict severity of pest problems in advance. Crops must be inspected regularly to determine levels of pests and natural enemies, and crop damage.

PPD survey personnel and agricultural extension agents can assist with field inspections. They can train farmers to differentiate pests from non-pests and natural enemies and to determine when crop protection measures, perhaps including pesticides, are necessary.

Step 4: Use All Control Methods Correctly and Safely.

Each pest control method has both advantages and disadvantages. PPD and extension agents should learn as much as possible about each control method. Education programs should be developed to teach farmers how to use the available control methods safely and correctly.

Step 5: Develop Education, Training, and Demonstration Programs for Extension Workers.

Implementation of IPM depends heavily on education, training, and demonstration to help farmers and extension workers develop and evaluate the IPM methods. Hands-on training conducted in farmers' fields (as opposed to a classroom) is a must. Special training for extension workers and educational programs for government officials and the public are also important.

IPM is a sensible approach to pest control whereby all existing control methods (pesticides, biological control, cultural control), mitigating factors, environmental concerns, climatic conditions, and ecosystem interrelationships are integrated to assist in control operation decision making. While pesticides are part of the total IPM strategy, other methods are considered, with the choice dependent on the methods that most closely fit the situation. Timing of pesticide application is an important factor in IPM, with the early season approach favored because of the low amount of pesticides used. IPM is not a pest control method itself, but is a way of systematically considering options available in light of the physical and biological environment.

3.6 Pesticide Management

While there are many methods of l/g management, the most commonly used is chemical pesticides. While pesticides kill pests, they also affect other living organisms in the ecosystems in and around cropping areas. In addition, misuse or overuse of pesticides results in higher overall operational costs. This is not only because of the direct cost of the pesticide, but also because of reduction in natural enemies in the crop ecosystem.

The possible impact of pesticides on the environment and associated health risks to humans makes the way pesticides are selected and used an important aspect of management programs. Due to the environmental and biological diversity of Botswana, pesticides should be used with extra caution, and only when necessary.

To use a pesticide in a specific area at specific time, it is necessary to have detailed knowledge of the physical and chemical attributes of the product, the ecology of the area to be treated, and the biology of the pest. Pesticide selection for l/g control requires the following concerning the pesticide itself:

- Effectiveness at low application rates;
- Minimal effects on nontarget organisms, including people and animals, and specifically predators and parasites of locusts and grasshoppers;
- Minimum persistence of residues on and in native fauna and flora, water, soil, and crops;
- Low toxicity and ease of handling;
- Good storage capacity;
- Compatibility with existing application equipment.

3.6.1 Pesticide Selection and Distribution

Although a number of pesticides have been used in Botswana against locusts and grasshoppers in the past, any pesticide involved in an operation funded by the USG must be approved for use in the United States by the Environmental Protection Agency (EPA). Several approved pesticides are listed in the Programmatic Environmental Assessment (PEA), and that document should be referred to during both the planning and implementation phases of l/g management. In addition, regulations governing the use of a particular pesticide, as set forth on the label, must be followed.

Malathion, Acephate, and the three synthetic pyrethroids (**Cypermethrin, Lambda-cyhalothrin, and Tralomethrin**) are among the pesticides preferred for use in terrestrial ecosystems. For use near aquatic ecosystems (or all cases with the possibility of contamination of water), **Acephate** would be the pesticide of preference from the environmental standpoint, as it is a systemic, and best used for larval control. In addition, **Acephate** is considered one of the safest pesticides in use. **Carbaryl**, suggested by the PEA, is toxicologically acceptable, but is more difficult to store and apply (especially from aircraft) than other approved pesticides and is very toxic to bees. **Diazinon** and **Chlorpyrifos** are registered for use; potential environmental problems indicate they should be used with caution. **Fenitrothion** should be used only with extra precautions and with mitigative measures. Water resources in Botswana should be protected from pesticide contamination as much

as practicable. Therefore, the pesticides preferred for terrestrial use should be the ones favored for USAID procurement.

Chlorinated hydrocarbons, such as Dieldrin and Lindane, are not acceptable for use under any circumstances, due to their environmental persistence, bioaccumulation, and acute toxicity. It should be noted that U.S. funds cannot be used in any way whatsoever in connection with these pesticides. This includes funding any aspect of ground or aerial application, support of aircraft which spray chlorinated hydrocarbons, or funding the transport of such materials, among others.

PPD is responsible for maintaining and distributing agricultural pesticide stocks in Botswana. Pesticides used in previous locust/grasshopper campaigns have been Fenitrothion 96% ULV and Deltamethrin 3% ULV (Appendix C). No formulation is done in the country, and almost all PPD stocks have been imported from RSA. The major depot is at PPD Headquarters in Sebele (Gaborone). Pesticides are distributed annually from there to the Regional and District Offices as needed operationally. Empty containers and much of the unused stock is returned to PPD Headquarters at the end of the control season.

Pesticides used for veterinary and public health purposes are also distributed by government agencies. The central storage site for veterinary pesticides is in Maun, and that for public health pesticides is in Francistown. There is also uncontrolled importation of pesticides in the private sector.

3.6.2 Pesticide Labeling

Pesticide labeling is a way to give important information to the pesticide user. The label is the main and often only medium for instructing users in correct and safe use practices. Part of the labeling process is pesticide registration by host countries. Both registration and proper labeling require good solid legislation at the national level. A Pesticide Act is currently in draft, and approval by Parliament is expected. Botswana has had no regulations governing imports, exports, and distribution of pesticides, and a strong program of enforcement of the existing licensing and labeling program components of the proposed legislation would be an important step in achieving safe use of pesticides.

The pesticide product label can be used effectively to communicate a number of important properties of the pesticide and precautions appropriate to its use. In addition to directions for use, the label should include needed protective measures, first aid measures, precautions recommending against use in certain environments, methods of container disposal, and application rates for particular pest species.

Pesticide labeling in Botswana tends to be variable, as no legislative standards are in place. In general, pesticides in the original container carry a label with adequate information for application. Some labels, though not all, include some information on first-aid or disposal. Unfortunately, some of the PPD-stocked pesticide containers have either lost the labels that did exist, or labels have been rendered illegible through handling and exposure.

While labeling must be specific to local needs and the social environment of Botswana, the FAO has prepared a global set of guidelines which can assist a labeling program. In addition to enforcing legislation, the GOB should insist that donated pesticides be labeled in comprehensive language as required by donor country law.

3.6.3 Managing Pesticide Stocks

A well maintained and secure pesticide storage facility is required before initiating a U.S. pesticide donation. With a good pesticide management system in place, both donated and purchased pesticides can then be controlled and utilized as needed. A good storage area should have a fenced and covered area for the pesticides. A pesticide storage warehouse should:

- 1) be isolated from dwellings in order to avoid fire, leakage, and water contamination;
- 2) be supplied with water in order to clean spills and fight fire;
- 3) be aerated to avoid toxic fume concentration;
- 4) have a current inventory of pesticide stocks;
- 5) have protection gear such as suits, boots, gloves, goggles and breathing masks;
- 6) have a first aid kit with antidotes;
- 7) be staffed with trained personnel who are familiar with measures to take in cases of poisoning.

A management system is needed to record the date each pesticide arrived at the facility, how long it stays in storage, and when it is removed for use. In addition, the storage requirements for each pesticide must be posted and known by the management staff. Stored pesticides must be tested periodically to insure that the active ingredient is as described on the label, and that the formulation concentration is correct. Also the disposal of unused and obsolete pesticides, and the destruction of their containers, must be part of the management system.

Success of locust and grasshopper campaigns depends on availability of pesticides in the areas which need treatment. Pesticides should be placed in a safe and secure storage area as close as possible to agricultural areas which will likely need

treatment. In Botswana, the major pesticide storage area is at PPD Headquarters, with distribution of products to Regional and Field Offices done according to need and severity of the locust/grasshopper threat. Pesticide stocks at Sebele are temporarily stored outdoors and uncovered as the warehouse is upgraded by installing a concrete floor, air ventilation, and drum handling equipment. Pesticide storage facilities at Regional and Field Offices are substandard, drums sometimes being stored outside and unsheltered. Spillage has been a problem.

Although the central storage facility in Gaborone is inadequate, upgrading which is now in progress should address the problem sufficiently. Improvements should be made in storage facilities at Regional and Field Offices. Care in management must be taken to prevent unwanted stock accumulation. This has been a very real problem for other countries involved in l/g management; a lack of planning and coordination has resulted in stockpiles of pesticides at some bases, and shortages at others. This seems to be a result of a lack of training in the managerial aspects of pesticide storage.

In addition to management of the pesticides themselves, the PPD District Offices must adequately manage pesticide application equipment. Some of this equipment, especially that obtained for locust control, is rather old; deterioration and lack of spare parts are problems. Nevertheless, the PPD must work to maintain what equipment it does have, and ensure that it is clean and in good working order.

3.6.4 Obsolete Pesticides and Containers

Once a pesticide has been used, the management operation is left with an empty container. This container can be either reused or destroyed. If reused it should be only be used for the same pesticide, to store fuel, or it can be flattened for use in construction after being properly cleaned. It should never, repeat never, be used to store water or food. Even though the pesticide is gone, enough is left to cause poisoning, especially in the very young or old. Further, small quantities of pesticides will make the human body more susceptible to other diseases.

Botswana, like other countries in sub-Saharan Africa, is faced with the problem of stocks of expired or substandard pesticides which were acquired through commodity aid programs or unplanned importations. Powder and liquid formulations of herbicides and organophosphate insecticides donated or purchased in the late 1980's have accumulated at the PPD Sebele warehouse. Drums are corroding and labels are absent or illegible. There is no policy developed which adequately covers disposal of such chemicals as well as empty containers. An empty drum-crushing

and burial disposal project had begun several years ago, but was abandoned due to economic and bureaucratic constraints.

3.6.5 Disposal of Unwanted Pesticides

When a pesticide is no longer needed, or is degraded chemically due to heat or time it will need to be disposed of. As many of the obsolete stocks are in liquid formulation, one disposal method is high-temperature incineration at a suitable facility. Incinerators in Europe or other countries may also be used for disposal operations. Disposal is a complex problem not yet clearly resolved in technologically advanced countries, but available methodology should be made available to developing countries at the earliest opportunity. Because of the current research in this area, and the potential for political ramifications, USAID/Botswana should consult AID/W prior to any pesticide disposal assistance program.

3.7 Cultural and Biological Management

Numerous non-chemical methods exist for pest management in general, and have been used against locust and grasshoppers. For example, crop varieties which develop at different rates from the commonly planted varieties, or which show resistance to insect attack, may be applicable in the long-term. Sorghum, for example, is more resistant to attack by grasshoppers than millet. Other cultural methods, such as trap cropping, residue burning, trench digging in front of locust larval path, and intercropping may well have merit as well. Simple techniques such as using protected courtyards for tree seedling nurseries or covering seedlings with mosquito netting can be effective in small scale and limited cases.

Farmer experience with traditional or innovative control methods should be encouraged and incorporated into an overall 1/g management program. If villagers can be recruited as participants in control efforts, such as a Village Brigade, a field can be protected with a minimum of pesticide use and expense.

Research on field use of microbial agents in locust and grasshopper control is currently being undertaken by USAID and other international organizations. The fungal pathogen Beauveria bassiana has been tested in the US and in parts of Africa for its control potential. Preliminary results from the U.S., Cape Verde, and Mali indicate that B. bassiana can be an important control agent, especially if used as part of an overall biointensive program. Additional work will be needed to determine its specific usefulness on the locust species in Botswana, but the geographically and ecologically circumscribed

Chobe District breeding areas of the Red Locust would seem to provide an ideal field situation for evaluation of fungal control techniques. Other fungal entomopathogen such as Metarhizium flavoveride being studied. M. spp. from Madagascar have shown to be highly virulen to l/g.

In working with microbial pest control agents, attention must be given to handling and application techniques. Some may have a short shelf life and must be used soon after production. In addition, climatic and environmental conditions in the field will impact the microbial control agent. Formulation appears to play an important part in the longevity of these materials under field conditions.

Another research recommendation is the search for local and possibly more species-specific pathogens. Large population explosions of l/g might be conducive to the development of epidemics of endemic pathogens. At the time of population collapse a search for more effective pathogens would be appropriate. Such a search should be done in collaboration with laboratories familiar with pathogen isolation.

Research is needed on plant extracts as bio-pesticides and antifeedants which may have use as components of IPM and may be appropriate for Botswana. AID/Gaborone is supporting University of Botswana research on antifeedant properties of plant extracts for use against corn crickets. This SEA encourages greater communication between PPD personnel and University researchers as a way to extend promising results in the laboratory into field situations. Some materials may already be used by villagers as a traditional means of insect control.

Other fruitful research areas might include use of synthetic insect growth regulators (IGR). These agents are considered alternatives to conventional pesticides because of their different modes of action, and incorporation of IGRs into the 1993 African Migratory Locust control program in Madagascar showed that the technique has promise. However, there may be impact on non-target aquatic invertebrates.

3.8 Safety and Health Care System

3.8.1 Public Awareness

In conjunction with USAID assistance in locust and grasshopper efforts, it is important that the Government of Botswana monitor both human health and the natural environment. In regard to protecting human health, it is necessary to educate both the medical community and pesticide applicators about the potential hazards of pesticides, and steps to mitigate these. Application of a pesticide in a given area should be preceded by

public awareness and extension activities and education of the users. The Botswana public must be informed that pesticides are dangerous and that empty pesticide containers should not be used for food or water storage. A good public information program would include:

- information on the specific pesticides and labels;
- safe methods of pesticide transport and storage;
- measures in cases of container leakage;
- conditions for pesticide use;
- safe use of application equipment;
- prevention of pesticide poisoning.

Pesticide educational programs can be instituted by agents from the Ministry of Health. Health education and extension programs can also provide information on first aid in pesticide poisoning cases. The inherent toxicity of used pesticide containers is an important subject area, and should be specifically directed to women who might use the containers for cooking or holding water. Components of a pesticide public awareness program should include photographs, posters, or prints on cloth. These should be given to agents as visual aids to hang on walls of schools, dispensaries, and on large trees in villages and towns.

Radio broadcasts are an important part of a public information campaign, including pesticide awareness information in the form of brief safety announcements, musical programs, 778interviews, debates, and dramas. Discussions of pesticide regulations and legislation should also be presented, including information on which pesticides are legal and which are prohibited in Botswana. This will allow potential buyers and users to know what pesticides should be accepted and what should be refused.

3.8.2 General Pesticide Safety Concerns

Because of the role pesticides can play in potentially increasing agricultural productivity, the Government of Botswana regards these chemicals a useful part of agriculture. Unfortunately, pesticides can be misused by both farmers and PPD agents, presenting hazards to the human environment and the natural ecology. For example, pesticides intended for agricultural or public health purposes may be misused for general household insect control.

In addition to the potential for unsafe application, pesticides may also affect public health by being stored improperly. It is important to keep stored pesticides in good condition, away from humans and other animals. Any unwanted or leaking pesticides must be repacked or disposed of as soon as possible. Because pesticides have the potential for misuse, it

is essential that existing legislation on pesticide use be enforced. While abuse may still occur, implementation of regulations will provide a sound base for promoting public health and environmental integrity.

3.8.3 Applicator Safety Training

USAID has supported pesticide applicator safety training in the past in Africa, and has found such training to be a useful and often sustainable use of funds. It is important that well-trained PPD agents are available to work with any U.S.-funded pesticide donation.

The incorporation of hands-on pesticide safety and application training courses into the academic curriculum for agronomy and other agricultural degrees is essential. This approach will allow trained individuals to interact with the actual users of pesticides.

Properly trained PPD agents and agricultural extension agents are encouraged to work with farmers in "Train-the-Trainer" programs. This type of training will allow essential information on pesticide safety and application to reach all who may be working with pesticides. This type of training is strongly encouraged by USAID

An additional approach is an emphasis on pesticide safety training among private suppliers of pesticides. PPD could work effectively with the private sector to ensure correct use of imported pesticides.

The Occupational Health Unit of MOH could cooperate with PPD in applicator safety training. It has recently produced a booklet on First Aid treatment for cases of insecticide poisoning.

3.8.4 Health Care System

Botswana's health sector depends upon a referral system which provides increasingly sophisticated services at successive levels (Table 1). In very remote areas, the first point of contact is the mobile stop, followed by health posts and clinics respectively. There are 308 health posts, 170 clinics, 13 primary hospitals, 6 government District hospitals, 3 mission hospitals, 3 mine hospitals, a government psychiatric hospital, and 2 national referral hospitals, and a new 107-bed private

Table 1. Health Facility Referral System and Criteria

Facility	Services provided	Description	Location and population
Mobile stop	- Limited PHC services.	No fixed facilities.	Very remote areas.
Health post	Community based worker as first contact. - primary health care, including family planning, environmental health, maternal/child health, school health; - first aid treatment of common diseases; - case finding/follow up; - periodic visits by mobile health teams.	3 rooms and toilet. House in remote areas.	500-1 000 in rural areas.
Clinic without maternity ward	- Maternal/child health; - preventative work (as health post); - diagnosis and treatment of common diseases; - simple laboratory tests; - case finding and follow-up with emphasis on TB.	5 rooms, covered area, toilets, vehicle, 2 staff houses.	5 000-10 000 in rural areas, 10 000 or more in major villages and towns.
Clinic with maternity ward	- As above, but including deliveries.	as above plus maternity unit, vehicle, 3 staff houses.	as above. Maternity ward depends on area's needs.
Primary hospital	- As at clinic; - supervision of clinics and health posts; - general in-patient care; - laboratory tests; - X-rays and surgery.	20-70 beds in total, 4-12 maternity beds; 16-58 general beds. Out-patient facilities.	Mainly in villages and remote areas. Depends on area's needs.
District hospital	- As at primary hospital; - specialist services for serious and complicated health problems; - preventive, curative and rehabilitative services; - in-patient care for more complicated health needs.	Primary hospital on a larger scale. 70-400 beds.	Major villages and towns.
National referral hospital	- As at district hospital; - specialist clinical services.	400+ beds.	Gaborone and Francistown.

Source: Ministry of Health.

clinic (Fig. 8.). Other private services include medical care provided by private health institutions, fee-for-service medical practitioners and pharmacies, as well as services provided by private companies to their employees. It is estimated that just over 85% of Botswana's population is within 15 km of a health care facility.

District health teams are the cornerstone of the Botswana's Primary Health Care (PHC) strategy. These are units within the Ministry of Local Government and Lands. Local authorities are administratively responsible for health posts and clinics, with the MOH providing professional supervision and technical support. MOH is directly responsible for all government hospital facilities.

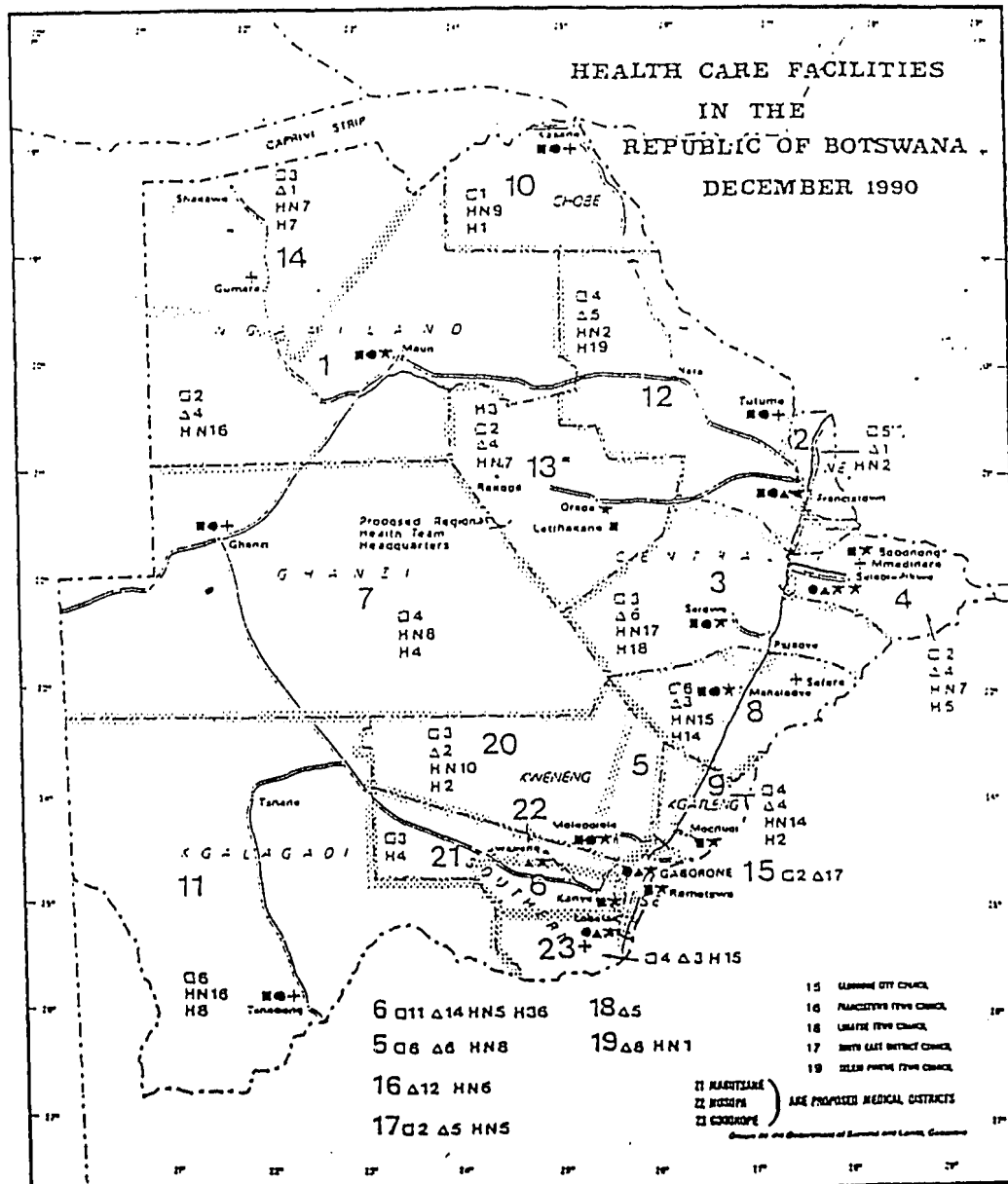
All hospitals and health centers in an area which is likely to be involved in a pesticide spray operation should be provided with information materials on the pesticides to be used in the area. The personnel of these centers should be given the necessary training to recognize and treat pesticide poisonings. Information is available in the EPA handbook on pesticide poisonings (Morgan, 1989).

The local health care delivery system in Botswana may not be equipped to handle a serious case of poisoning, which, if it occurs, is most likely to involve an applicator. Therefore, application crews need to be self-sufficient in handling medical emergencies. Supervisors must be familiar with safe handling of pesticides and be able to administer any needed first aid, including antidotes for pesticide poisoning. All who are working with pesticides should be familiar with the early warning signs of poisoning. Workers must be removed from contact with pesticides at the first signs of poisoning.

3.8.5 Potential for Human Health Impact

The potential for adverse effect on human health increases significantly when pesticide use is high. When large areas of the country are treated and large quantities of chemicals are being shipped distributed, and applied, the probability of exposure of humans (and the environment) is proportionately greater. This SEA advocates prevention of human exposure as the best approach to minimizing adverse health impacts. A major aspect of prevention is to keep locusts at low population levels with preventative control strategies, as discussed in the previous section. Another major aspect, covered in this section, is prevention of human exposure.

Figure 8. Health Care Facilities, 1990



3.8.6 Prevention of Human Exposure

The general population is most effectively protected from any adverse health effects by proper pesticide application techniques. Whether or not the application is safe for the general population depends on the toxicity of the pesticide, the formulation used, the concentration of the pesticide in the formulation, the frequency of application, the kind of equipment used, and the training of applicators in safety precautions. In areas of high population densities, treatment-free perimeters can be observed in order to avoid exposure.

This SEA advocates training, educating, and supervising the applicators as the most effective way to ensure that exposure of the general population is kept at or below acceptable levels. Such training and supervision has to be an ongoing effort and has to be detailed enough to include the differences among individual pesticide active ingredients, formulations, and application methods.

The general public is at minimal risk if the necessary precautions are taken, but should nevertheless be informed about pesticide use. This can be achieved by a number of means, such as posters, the radio and local newspapers. Public health advisories given by radio broadcasts were effective in other countries prior to past aerial applications and should be included in plans for future applications. This is especially important in areas where people may eat locusts. It also should include public education about the dangers of improper pesticide container reuse.

Pesticide applicators are generally at the highest risk for any adverse effects. The risk level is much higher than that of the general population because applicators are handling concentrated products. In addition to the training and supervision indicated above, applicators should be thoroughly familiar with the level of danger from the pesticide, and should be provided with equipment that is in good working condition in order to minimize accidents. Such equipment may include pumps to transfer pesticides, body protection in the form of gloves and aprons, safety shields for the face to prevent dermal exposure, and respirators to prevent inhalation.

It is particularly important that some form of protection is worn during the short periods while handling the concentrates. If at all possible, long-sleeved shirts and full-length pants should be used, and washed frequently. PPD logos or patches on the protective clothing items can help induce use and care.

Exposure of applicators is mostly through the skin. Though the skin usually provides a significant barrier to the entry of

some pesticides, even these will penetrate into the body if the contamination is left on the skin. In addition, some pesticides penetrate the skin more readily. Therefore, applicators should wash any exposed areas of the body frequently. If water is scarce, the wash water could be saved for use in diluting pesticides.

3.8.7 Monitoring of Human Exposure

Simple and effective health monitoring of those involved in pesticide handling, application, and storage is essential to a good management operation. This involves teaching all involved with pesticides what the symptoms of pesticide poisoning are, and when first-aid might be required. It is especially important to use behavioral observation to decide if workers should be immediately removed from pesticide exposure.

The GOB should have the capability to monitor both behavioral symptoms of pesticide poisoning, and such blood-chemistry manifestations as acetylcholinesterase (AChE) inhibition. Testing for AChE inhibition is fairly simple and inexpensive, and can be performed by trained health workers in the field. The background cholinesterase level for each person involved with pesticides must be determined prior to exposure, and testing should be performed at intervals throughout the season to ensure that no worker is being overexposed to pesticides. (It should be noted that testing AChE is recommended only when pesticides in the organophosphate class are used, e.g. Malathion, Sevin, etc.).

AChE is not done presently by either PPD or Occupational Health. There is no supply of kits in the country; Occupational Health is interested in training sessions for its technicians should the kits become available, and would be the agency responsible for monitoring AChE.

Measurement of residue levels in the environment can also be a valuable source of information for assessing exposure and determining if modifications to treatment operations are needed. At present, the PPB is dependent on technical documentation to evaluate non-target effects of pesticides. There is concern about analysis of pesticide residues, especially on food materials. A residue analysis laboratory routinely monitors meat products for export, and with adequate legislation and increasing agricultural exports there is a need for extending residue analysis to other food materials. This SEA supports development of such a facility, perhaps on Southern Africa regional basis, as data are lacking on pesticide degradation under local conditions and on residue persistence on food crops.

3.9 Environmental and Non-target Impact

3.9.1 Environmental Impact Minimization

Due to their toxic nature, pesticides will impact both crop and nearby ecosystems. Care must be taken during the handling, transport, application, and disposal process to insure that as little impact as possible is allowed in non-target areas. In addressing this issue in regard to operational planning, risks to the environment must be considered in terms of early season management, versus late season large-scale operations. The latter would involve considerably greater amounts of pesticide, and correspondingly greater risks.

Because of the additional risks incurred in late season control operations, USAID/Botswana should support management operations designed to avoid such risks. Early season survey and management can prevent late season control operations, with significantly less pesticide usage. Preventive management operations emphasizing surveys which locate and delimit pest populations, and spot treatment operations intended to reduce population numbers using as little pesticide as possible are favored.

Because the number of hectares sprayed is reduced, early season control operations use less fuel. Vehicle wear is also reduced and vehicles will last longer. Because early season control strategy uses considerably less resources, PPD can be better able to implement it without donor assistance. A greater degree of self-sufficiency and control of the situation by PPD itself is allowed.

If pesticide use is necessary, the type of ecosystem in the treatment area, and associated non-target species, should be major factors in determining the choice of pesticide. A pesticide's characteristics, such as selectivity, mobility in ground water, persistence, and metabolic products should be considered as important as effectiveness against target species. In addition, application methods should be considered, with ground application having less impact than aerial treatment.

The response of different animals and ecosystems to pesticide exposure varies dramatically. For example, carbaryl has only low toxicity to birds, but is extremely toxic to aquatic invertebrates and certain estuarine organisms. While application of carbaryl may be appropriate in areas providing upland habitat for birds, its application in areas important to waterfowl and migratory shorebirds, such as lakes, wetlands, or coastal areas should be prohibited.

Although this SEA strongly recommends against any pesticide applications in aquatic systems, acephate is relatively nontoxic to freshwater fish and invertebrates, and is the least likely of the selected pesticides to have adverse effects on aquatic habitats. Acephate should be one of the preferred pesticides if applications are necessary adjacent to aquatic systems, particularly in and around fragile areas or critical mammal, bird, or fish habitat. Due to its mobility in soils, however, acephate has the potential to contaminate ground water.

3.9.2 Environmental Monitoring

Part of the overall pest management system is monitoring treated areas for potential environmental effects of pesticides. Monitoring can indicate negative impacts on flora and fauna, as well as detect improper application methods which can impact human health and increase operations cost. Measuring pesticide residues in the environment is an excellent way of monitoring, and require a residue analysis laboratory for full implementation. Pesticide use support should incorporate residue analysis into their project plans, and should include qualitative behavioral observations of non-target organisms near any pesticide target areas. PPD applicators must be trained to note unusual behavior among fauna of the area, and the practice of having control teams in vulnerable areas accompanied by a District Wildlife Officer should be continued.

Although monitoring is likely to produce variable results, it can be a valuable feedback tool in control operations. It can provide some general conclusions on effects and can be used in designing modifications of pest management activities. Given the large number of variables that can affect results and the limited resources likely to be available for monitoring, the most practical ways to assess the effects of pesticide applications may be mortality and population counts and behavioral observations. Baseline conditions for an indicator species and its habitat should be determined prior to pesticide application, and post-application monitoring should be conducted at intervals sufficient to allow assessment of both immediate and long-term effects. It is also important to select species with demonstrated sensitivity to pesticide exposure. The Norwegian Agency for Developmental Cooperation (NORAD) has shown interest in supporting baseline environmental research in Botswana, and might be approached in this regard by PPD.

Aquatic habitats are often critical habitat to sensitive species and migratory birds. Therefore, pesticide use near such habitats should be avoided whenever possible. Care must especially be taken when pesticides are applied during or close to times of seasonal rains. This may lead to introduction of the pesticide into water supplies or aquatic systems in runoff.

Because invertebrates are generally much more sensitive to insecticides than vertebrates, monitoring the observable effects of pesticide use on invertebrates, such as benthic organisms, should be the preferred method for monitoring aquatic habitats. Vertebrates, however, should not be ignored, as pesticide effects on them may be indirect, but no less severe.

A similar monitoring approach should be used for pesticide use in terrestrial ecosystems. Selection of soil microorganisms or other low-tolerance invertebrates as indicator species is recommended. Monitoring animals of economic value or threatened status should also be required. In cases where pesticide persistence is an issue, residues should be measured. Populations of vertebrate predators, such as birds or prey, are likely to fluctuate too much to make population counts an effective monitoring tool. However, reproduction monitoring of carnivores (e.g., observations of egg conditions, birth defects, infant mortality) may be a useful tool in determining the effects of pesticides known to affect reproductive success, particularly in cases where baseline data are known.

4.0 PROTECTED AREAS/PROTECTED ANIMALS AND PLANTS

Because pesticides will impact both crop and natural ecosystems, some system of natural resource protection is necessary. This can be accomplished by setting aside areas and zones where pesticides are not used, or are severely restricted. Endangered animals and plants need to be taken into consideration in regard to habitat intervention. Since birds and fish are particularly vulnerable to direct and indirect impacts of pesticides, these organisms need to receive special consideration. Some areas should be set aside to be protected from pesticide use no matter how great the perceived pest control need.

Protection of animal and plant species and their habitat in turn preserves the regional biological diversity. In addition to protecting habitat and inherent existence value, Protected Areas also provide a safe place for reproduction and regeneration of wildlife after losses from drought and poaching. They provide for Botswana's important tourism industry which, because it is relatively non-consumptive, has a high return value. In addition, protected plants may hold value for future industrial and pharmaceutical use. Protected areas can also contribute to local village economy through value-added income.

Botswana's DWNP is concerned with protection of fragile areas and conservation of biodiversity. Several NGOs, such as the Kalahari Conservation Society, also promote policies and research that conserve wildlife and their habitats. This SEA recommends that mitigative measures associated with any l/g control activity be coordinated with activities of DWNP and appropriate NGOs.

Unfortunately, overgrazing and basic economic needs are contributing to degradation of forests and grasslands in Botswana, and habitat for many of Botswana's plant and animal species is being lost. Drought and erosion further accelerate this habitat deterioration. **It is extremely important that any U.S.-funded locust/grasshopper control program involving pesticides not contribute further to the environmental degradation already underway. Further, the United States should do its utmost to use methods and materials that have the least toxic effects on both crop and natural ecosystems.**

Fishing is primarily restricted to northern Botswana, where fish as a protein source support much of the population in the Okavango and Chobe waters, and provide livelihood to fishermen and people in associated industry. Fish populations are liable to be indirectly affected by pesticides used in locust or grasshopper control operations because of direct toxicity to aquatic invertebrate fauna (Keith, 1989). As the fisheries are

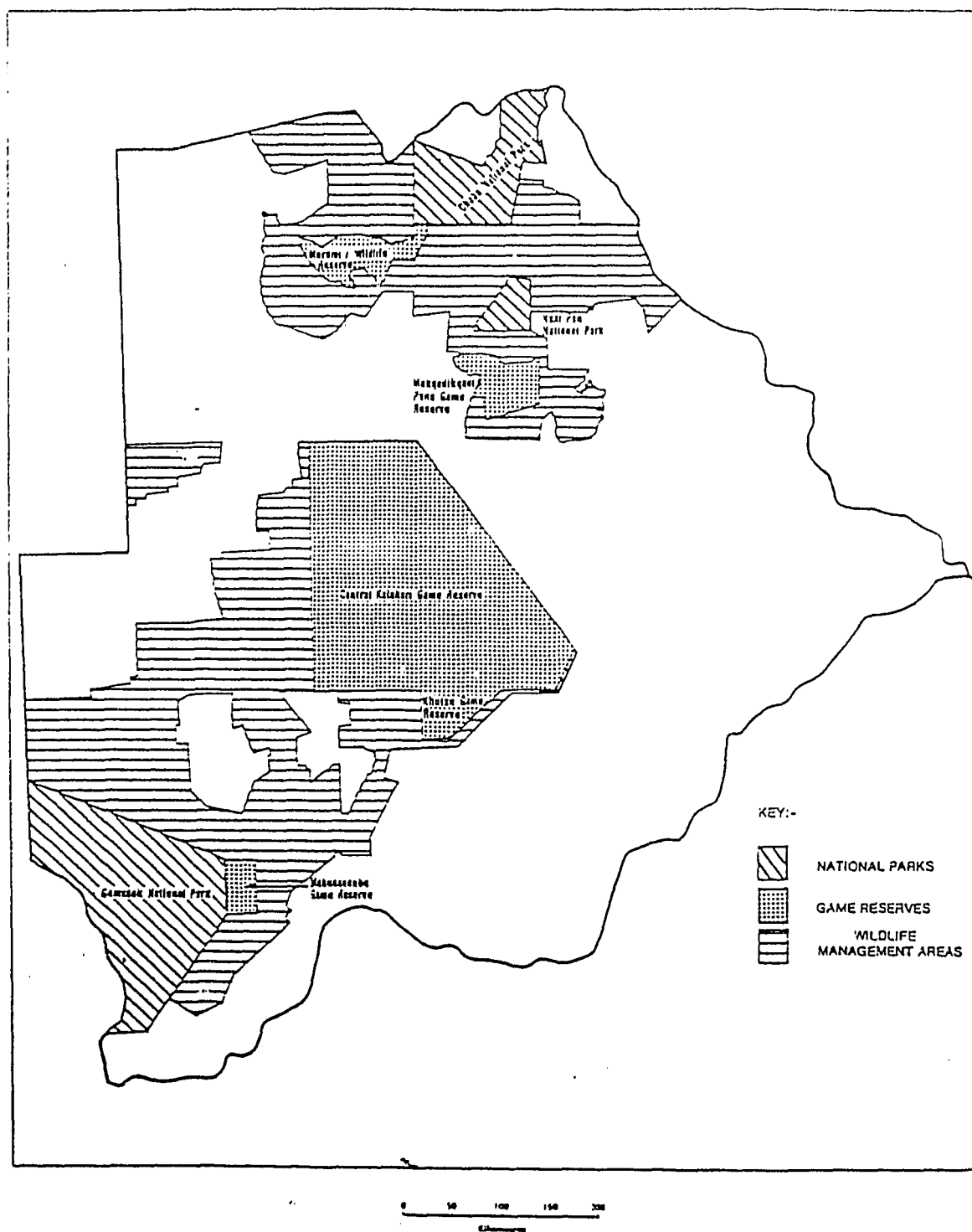
located in areas subject to locust invasion, they may be especially at risk as locust control efforts are implemented.

4.1 Protected Areas

Botswana has 17% of its land area designated as National Parks or Game Reserves. All resources are protected in National Parks; animal populations are protected in the Game Reserves. An additional 23% of Botswana's land area is occupied by Wildlife Management Areas, in which it is intended that the main land use is as wildlife habitat. The three National Parks and five Game Reserves extend from north to south through the central and western parts of the country (Fig. 9). The Central Kgalagadi Game Reserve (5,100,000 ha), which is very arid, is the largest of the conserved areas in Botswana. Gemsbok National Park (2,500,000 ha) is the largest of the National Parks and is situated in the drier south-western Kgalagadi. Chobe National Park (1,100,000 ha), the second largest National Park, contains a rich variety of wildlife, as it is situated in the wetter northern part of Botswana. The Makgadikgadi Pans Game Reserve (390,000 ha) consists mainly of salt pans. The Moremi Game Reserve (390,000 ha) is located within the Okavango Delta, and contains a wide variety of flora and fauna associated with the swamps. The Khutse Game Reserve (250,000 ha), on the southern boundary of the Central Kgalagadi Reserve, is very dry. The Nxai Pan National Park (210,000 ha), the smallest of the parks, is located near another set of salt pans. The Mabuasehube Game Reserve (180,000 ha) is adjacent to Gemsbok National Park.

Animal biodiversity in Botswana is high with 164 mammal species, 550 birds, 157 reptiles, 80 fish, and 38 amphibians. The parks, reserves are habitat for a wide variety of plains and forest mammals, ranging from herbivores such as various antelopes, giraffes, zebras, elephants, rhinos, and buffaloes to predators like lions, cheetahs, and various wild cats and hunting dogs. The wetlands of the Okavango Delta and Chobe are important to a diverse and abundant bird fauna. It is critical to consider the importance of these habitats, and the direct vulnerability of birds to pesticide toxicity, in implementing any locust or grasshopper control operations involving pesticide spraying. A further illustration of the importance of the Okavango and Chobe regions is the fact that mammal populations in other parts of Botswana have shown a drought-related decline over the past decade; in the Okavango and Chobe populations have remained stable, with the presence of permanent water and floodplain conditions moderating the effects of the drought on animal populations. These are all environments which are responsible for the growing importance of the tourist industry to Botswana's economy. It is now equivalent to agriculture and manufacturing in its contributions to Gross Domestic Product. More than 20% of visits by non-residents to Botswana are for tourism, exceeding

Figure 9. National Parks, Game Reserves,
and Wildlife Management Areas



BEST AVAILABLE DOCUMENT

those for business purposes. Hotel and tourism-related activities are growing at a rate of 15% per year, and 40% of all formal sector jobs in the northwestern part of the country are linked to tourism.

This SEA commends PPD's decision to avoid spraying in Chobe National Park during the 1993-94 outbreak of African Migratory Locust and Red Locust. Swarms had actually entered the Park, and PPD showed considerable foresight and thoughtful restraint in avoiding treatment of this fragile area. Fortunately, the invaded park areas proved to be unsuitable sites for locust breeding.

Forest reserves constitute only about 1% of Botswana's land area. They are located in the northern Chobe District. They are administered by MOA, but receive little protection due to lack of staff and resources.

Protected areas should be surrounded by buffer zone at least 5.0 km wide. These are needed to avoid accidental pesticide application and possible spray drift, and will help to minimize indirect effects of pesticide use. Within buffer zones, higher priority should be given to use of alternatives to chemical pesticides, and a monitoring program so that non-chemical alternatives can be applied successfully. As the capacity of the PPD to provide training in non-chemical alternatives increases, the width of the buffer zones can be increased.

4.2 Non-Protected Sensitive Areas

In addition to these protected areas, the PPD should take precautions in a number of other areas that have a lower level of vulnerability, but which are still ecologically sensitive. Many of the protected areas are not self-sufficient ecosystems, and wildlife moves in and out seasonally. The wildlife migration corridors need to be considered, as do large regions outside the park and reserve system which also harbor considerable wildlife. These areas can be designated as high priority areas for Village Brigade mobilization, intensive monitoring, and encouraging non-chemical methods of control. The areas would also include buffer zones around all territories designated above as fully protected zones, given their sensitivity to indirect effects.

Wetlands are particularly fragile environments, and much of the Okavango Delta and Chobe surface water resources lie outside National Park protection. The Okavango Delta and Kwando/Chobe/Linyanti river systems represent 95% of Botswana's surface water. The Limpopo and Marico Rivers form the border with RSA, and a number of seasonal rivers drain from eastern Botswana into this system.

The implementation of fragile area protection programs must lie with the GOB itself. Enforcement of regulations to ensure sensitive areas are actually protected is to the ultimate benefit of the people of Botswana, and must therefore be made a priority. The effectiveness of protection programs is closely linked with integration of local populations to build a feeling of responsibility. Donors should monitor the protection program, assisting it if necessary, and they may even wish to base funding levels on the level of GOB commitment for environmental protection.

4.3 Protected Animals and Plants

Numerous plant and animal species are listed as endangered or threatened in Botswana, and Appendix E lists mammals, birds, and reptiles which have received "protected" or "partially protected" designations from DWNP. **It should be articulated to GOB and the donor community that no U.S.-funded pesticides will be applied or related operations take place in or around established critical habitat.**

Many populations of endangered and threatened species continue to decline despite legislation. Some are jeopardized in different parts of the migratory range: populations of the lesser kestrel, a specialized feeder on grasshoppers, have already been greatly reduced by grasshopper control programs in the Russian steppes; this species overwinters only in the Kgalagadi of Botswana. Several other animal species may cease to exist unless a considerably higher level of protection can be brought to bear. Any U.S.-funded operation must consider the potential impact of pesticides on these already strained habitats and the flora and fauna contained therein. While the value of human life cannot be placed below that of an endangered species, the U.S. should not allow itself to be drawn into a situation that may force such a choice. Here again, early survey and surgical treatment programs can allay such situations.

4.4 Pesticide Alternatives in Sensitive Areas

Farmers living in areas which have been designated as environmentally sensitive should receive training in IPM and the use of control methods which do not use chemical pesticides. These farmers should be encouraged to use traditional methods and should be informed as to how pesticides are dangerous to both humans and the environment. Farmers in such areas should be given individual attention, time to ask questions, and opportunity for discussion. PPD trainers should have a basic knowledge concerning food chains and the indirect effects of pesticides.

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APPENDIX A
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APPENDIX B

PEA for LOCUSTS/GRASSHOPPERS: SYNOPSIS OF ENVIRONMENTAL ASSESSMENT PRIORITIES

(The boldface is the recommendation made by the PEA for AID/W to continue its l/g, AELGA, IPM, etc.-type activities. The response is that of this document to the PEA recommendation, indicating that all of the below activities should be carried on as appropriate to Botswana conditions.)

BASIC PRE-CONDITION OF PROGRAM

Recommendation 1. It is recommended that USAID continues its involvement in Locust and Grasshopper control. Operationally, the approach to be adopted should evolve toward one of Integrated Pest Management (IPM).

This recommendation should be applied in the context of the specific needs of Botswana. USAID/Botswana supports IPM in the management of locusts and grasshoppers, as well as other insect pests.

INVENTORY AND MAPPING PROCEDURES

Recommendation 2. It is recommended that an inventory and mapping program be started to determine the extent and boundaries of environmentally fragile areas.

This recommendation can be part of future USAID/Botswana involvement with assistance efforts. Maps should include specific areas to be protected, some with a total ban on pesticides for grasshopper or locust control and some with a high priority for restricted use of pesticides. Areas which may have potential for the testing of pesticide alternatives should also be included.

Recommendation 3. It is recommended that a system for dynamic inventory of pesticide chemical stocks be developed.

Because of past inadequate management practices in Botswana, stocks of pesticide have been allowed to accumulate and degrade. In addition, stored pesticides are not always handled carefully or tracked to insure correct use and disposal. Improvements in the system for managing pesticide stocks must be implemented to protect human health and the environment and to minimize chances of pesticide products becoming obsolete.

Recommendation 4. It is recommended that USAID take an active role in assisting host countries in identifying alternate use or disposal of pesticide stocks.

A plan for managing obsolete stocks has been drafted with the support of USAID Washington. This should include the periodic testing of stored pesticide stocks to insure that the material is usable. Unwanted stocks in Botswana should be disposed of only with technology that best fits the local situation. High priority should be placed on minimizing the future accumulation of any unwanted pesticide.

Recommendation 5. It is recommended that FAO, as lead agency for migratory pest control, be requested to establish a system for the inventory of manpower, procedures and equipment.

This SEA supports that recommendation as an AID/W-coordinated and supported activity.

MITIGATION OF NON-TARGET PESTICIDE EFFECTS

Recommendation 6. It is recommended that there be no pesticide application in environmentally fragile areas and human settlements.

Any future spray operations or pesticide donations for use in Botswana should be accompanied by a requirement prohibiting use in some areas and limiting use in others and requiring appropriate buffer zones. The areas of total prohibition are designated wetlands, national parks, national forests, and fragile areas. Buffer zones and other reserves should restrict pesticide use, and encourage traditional and non-chemical methods. Villages, towns, cities, or any other human settlement will not be sprayed.

Recommendation 7. It is recommended that pesticides used should be those with the minimum impact on non-target species.

Pesticide recommendations in the PEA and as amended then after (State Cable #118768, 4/19/93) should be followed until research results indicate that more environmentally safe pesticides are available for use. Investigation of traditional and cultural methods of control is also strongly encouraged as a USAID/Botswana activity. This SEA does not contain a list of pesticides because it accepts the pesticide selection in the PEA.

Recommendation 8. It is recommended that pre- and post-treatment monitoring and sampling of sentinel organisms and water and/or soils be carried out as an integral part of each control campaign.

This recommendation should be implemented to some extent if possible, but may be difficult to fully implement in Botswana, due to both the expense and a lack of supportive infrastructure. A program of research monitoring is important both as a basis for design of operational monitoring and as a means of establishing statistically verifiable base line data. In addition, periodic sampling observations of target and non-target mortality, population numbers, and behavior should be made at locations involved in pesticides use.

APPLICATION OF INSECTICIDES

Recommendation 9. It is recommended that one of the criteria to be utilized in the selection of control techniques should be the minimization of the area to be sprayed.

A number of operational procedures should be followed to minimize the area to be sprayed. 1) Emphasis should be on an early and vigorous surveillance program, thus allowing early treatment operations and reducing the amount of pesticide used; 2) Crop protection operations should utilize economic thresholds to the extent possible; 3) A program of identifying non-treatment areas and minimum treatment areas should be adopted; 4) Training of all decision-making individuals should emphasize the importance of restraint in use of pesticides; 5) Farmers and villagers should be included in training and subsequent survey and application operations.

Recommendation 10. It is recommended that helicopters should be used primarily for survey to support ground and air control units. When aerial treatment is indicated, it should only be when very accurate spraying is necessary, such as close to environmentally fragile areas or for localized treatment.

The treatment program in Botswana should emphasize early season ground application. However, during rainy season treatment operations, road conditions may necessitate the use of aircraft. In addition, some areas may not be accessible except by helicopter. The AID/W (Forest Service) Aerial Application Guidelines should be followed in any such operation.

Recommendation 11. It is recommended that, whenever possible, small planes should be favored over medium to large two- or four-engine transport types {for application of pesticides}. In all cases, experienced contractors will be used.

This SEA supports this recommendation. However, large aircraft may be needed in Botswana to spray areas far from supportive infrastructure.

Recommendation 12. It is recommended that any USG-funded locust/grasshopper control actions which provide pesticides and other commodities, or aerial or ground application services, include technical assistance and environmental assessment expertise as an integral component of the assistance package.

This SEA agrees with this recommendation. In addition, this SEA strongly supports both long- and short-term training to be integrated with USAID-provided technical assistance.

Recommendation 13. It is recommended that all pesticide containers be appropriately labeled.

This SEA agrees with the recommendation and urges the GOB to give high priority to enforcing pesticide legislation and implementing laws requiring a good clear label. It is suggested that the GOB follow the FAO pesticide label guidelines.

DISPOSAL OF PESTICIDES

Recommendation 14. It is recommended that USAID provide assistance to host governments in disposing of empty pesticide containers and pesticides that are obsolete or no longer usable for the purpose intended.

USAID/Washington and the FAO are currently developing guidance on disposal programs for unwanted pesticides and empty containers. In addition, several pilot disposal projects are being implemented. USAID/Botswana should follow such disposal guidance when available, and should continue to assist with proper pesticide management. Proper disposal of empty barrels is especially important.

PUBLIC HEALTH AWARENESS

Recommendation 15. USAID should support the design, reproduction and presentation of public education materials on pesticide safety (e.g., TV, radio, posters, booklets). This would include such subjects as safely using pesticides, environmental awareness, pest management techniques of locusts and grasshoppers, and the potential hazards of pesticides. The goal would be to enable policy makers and local populations to recognize and avoid potential health problems related to pesticide applications.

Collaboration between the MOA and other ministries should ensure the development of public and applicator education on pesticide safety, pesticide poisoning recognition, avoidance, and treatment. In addition to receiving information on general pesticide awareness, the public should be made aware of the need to protect environmentally sensitive areas from pesticide misuse. Radio is an extremely effective medium in this regard, and should be utilized to its fullest.

Recommendation 16. It is recommended that training courses be designed and developed for health personnel in areas where pesticides are used frequently.

This SEA supports this recommendation and advocates inter-governmental collaboration in training programs.

Recommendation 17. It is recommended that each health center and dispensary located in an area where pesticides are used be provided with posters describing diagnosis and treatment of pesticide poisonings, as well as medicines and antidotes required for treatment of poisoning cases.

This SEA supports this recommendation, and advocates collaboration between the PPD and the Ministry of Health in appropriate implementation.

Recommendation 18. It is recommended that presently available tests for monitoring human exposure to pesticides should be implemented in the field. This includes measurement of cholinesterase levels in blood as a screening and indicator test for pesticide handlers and applicators.

This SEA supports the need to monitor the health of pesticide applicators and handlers during control operations. It is especially feasible to monitor blood cholinesterase in individuals working with organophosphate pesticides. This should

be implemented on a regular basis with pesticide handlers and applicators. In addition, this SEA favors behavioral monitoring for symptoms of pesticide exposure.

PESTICIDE FORMULATION AND MANAGEMENT

Recommendation 19. It is recommended that the specifications for USAID purchase of locust/grasshopper insecticides be adapted for all insecticides.

This is an USAID/W activity that should be implemented through a revision of USAID's Pest Management Guidelines, currently underway. No Botswana-specific recommendation is included in this SEA as it is a central and regional activity.

Recommendation 20. It is recommended that pesticide container specifications be developed.

This is an USAID/W activity that should be implemented through a revision of USAID's Pest Management Guidelines. USAID is working with the EPA Pesticide Disposal Workgroup to achieve state-of-the-art pesticide container specifications.

BIOLOGICAL CONTROL

Recommendation 21. It is recommended that Beauveria and other biological agents such as plant extracts be field tested under African and Asian conditions in priority countries.

USAID/W is currently supporting research on bio-pesticides in Africa. The need for carefully controlled studies in the area of biological control is stressed by this SEA. Other areas of research should be pursued, especially in regard to native populations of parasites, diseases and predators. USAID/Botswana may wish to support training and local research in this subject area.

TRAINING

Recommendation 22. It is recommended that a comprehensive training program be developed for USAID Mission personnel who have responsibility for control operations. This will involve a review of existing materials and those under development, in order to save resources.

This SEA supports that recommendation for Botswana. The L/G Operations Handbook (USAID, 1989a) fulfills this need in part, as does the PEA and this SEA. Other materials include regional meetings and workshops, and short-term technical assistance.

Recommendation 23. It is recommended that local programs of training be instituted for pesticide storage management, environmental monitoring and public health (see Recommendation 16).

This SEA supports this recommendation, and recommends that high priority be given to training on the safe and appropriate application of pesticides. Training can take the form of courses, as well having as individuals work with outside technical expertise. "Train the trainer" programs are especially effective in passing information with minimal expense.

Recommendation 24. It is recommended that when technical assistance teams are provided they be given short-term intensive technical training (including language if necessary) and some background in the use and availability of training aids.

This SEA supports that recommendation as an USAID/W activity. The overall preference is to have technical assistance teams with the needed technical expertise and sufficient language fluency for the tasks to be performed.

ECONOMICS

Recommendation 25. It is recommended that field research be carried out to generate badly needed economic data on a country-by-country basis.

This SEA supports this recommendation. Implementation in Botswana might consist of an agricultural productivity analysis along with an annual agricultural database program. This should include a research study on crop loss analysis.

Recommendation 26. It is recommended that no pesticide be applied unless the provisional economic threshold of locusts or grasshoppers is exceeded.

Due to the erratic nature of these insects, along with potential for social impact, a valid intervention (economic) threshold will require both the long-term collection of quantitative data, and research to determine the extent to which agricultural productivity is threatened. In light of this, it is important that intervention decisions, especially those involving pesticides, are supported by valid professional judgement. This would ensure minimum pesticide procurement by limiting USAID participation when a reasonable probability of substantial threat to crops does not exist.

ENVIRONMENTAL POLICY

Recommendation 27. It is recommended that USAID provide assistance to host countries in drawing up regulations on registration and management of pesticides and the drafting of environmental policy.

This SEA supports that recommendation. AID/W and EPA are developing an assistance program to assist with pesticide regulations and policies, including human safety, environmental impact, and use, storage, and disposal. Implementation should include improvement of pesticide labeling, including clear precautionary statements, specific use directions, and appropriate instructions for disposal of empty containers. In addition, policy must include an environmental monitoring program, with results used in the planning of future pesticide use operations, as well as detection of possible misuse or unexpected adverse results.

PESTICIDE USE POLICY

Recommendation 28. It is recommended that a pesticide use inventory covering all treatments in both agricultural and health programs be developed, on a country-by-country basis.

This SEA supports that recommendation, and considers this to be a topic appropriate for GOB action. Such a pesticide inventory program, done in conjunction with good storage management, can prevent the build-up of obsolete stocks, and thereby reduce overall operations and storage costs.

PESTICIDE HANDBOOK

Recommendation 29. It is recommended that USAID produce a regularly updated pesticide handbook for use by its staff.

This SEA supports that recommendation as an USAID/W or REDSO activity. Among the relevant activities in this area are USAID policies concerning pesticide use, efficacy and agricultural productivity, environmental impacts and health effects, and safety and mitigative measures. The Handbook should contain health, safety, and environmental assessments of pesticides that are likely to be used in Botswana.

SUPPORT AND TRAINING

Recommendation 30. It is recommended that technical assistance, education and training, and equipment be provided to crop protection services of host countries with a view to making the services eventually self-sustaining.

This SEA supports this recommendation, but only with a thorough analysis of actual needs, existing supportive infrastructure, and the ability of the PPD to manage a sustainable program.

STORAGE

Recommendation 31. It is recommended that more pesticide storage facilities be built. Until that occurs, emergency supplies should be pre-positioned outside Botswana.

This SEA supports this recommendation, and considers this a valid activity for Botswana. Due to inadequate storage facilities that currently exist in Botswana, support is for the regional Pesticide Bank concept (e.g., with IRLCO/CSA). A thorough evaluation of storage facilities should be completed prior to project assistance.

FORECASTING

Recommendation 32. It is recommended that USAID make the decision whether to continue funding forecasting and remote sensing (FEWS) or to use IRLCO's and FAO's early warning program.

This SEA is in favor of continuing and improving forecasting as an USAID/W or FAO activity. The IRLCO-CSA may also have the capacity as a regional forecasting entity.

PUBLIC HEALTH MONITORING AND STUDY

Recommendation 33. It is recommended that a series of epidemiological case-control studies, within the countries involved in locust and grasshopper control, should be implemented in areas of heavy human exposure to pesticides.

Although this is a valid activity for Botswana, a lack of supportive infrastructure would require that such a research program be accomplished with outside expertise and facilities.

RESEARCH

Recommendation 34. It is recommended that applied research be carried out on the efficacy of various pesticides and insect growth retardants and their application.

This SEA supports this recommendation, including the search for other microbial pathogens of locust and grasshopper species as a longer term priority.

Recommendation 35. It is recommended that applied research be carried out on the use of plant extracts as anti-feedants.

Several plant extracts in Botswana are worth investigating for bio-pesticide activity, thus deserving additional field research. As additional funds are available, the most promising options should be pursued.

Recommendation 36. It is recommended that research be carried out to determine the best techniques for assessing the impacts of organophosphates used for locust and grasshopper control in relation to the use of these and other chemicals for other pest control programs.

This SEA considers such comparative impact research an appropriate USAID/W activity. A major international research effort has been launched in Senegal on the ecotoxicological effects of locust insecticides.

ENHANCING AND ACCELERATING IMPLEMENTATION

Recommendation 37. It is recommended that USAID, on the basis of the previous recommendations, develop a plan of action with practical procedures to provide guidance in locust/grasshopper control to missions in the field.

This SEA supports this recommendation. USAID/W has a general plan of action that includes the development of Supplementary Environmental Assessments in the countries that are most critical for locust and grasshopper control. These countries include Burkina Faso, Cameroon, Chad, Eritrea, Ethiopia, the Gambia, Kenya, Madagascar, Mali, Mauritania, Mozambique, Niger, Senegal, Somalia, Sudan, and now Botswana. These SEAs will, in turn, contain commitments for future actions. Country-specific plans of action will be developed to implement

those commitments when needed. The country-specific plans of action will be the backbone for guidance of locust/grasshopper control activities.

Recommendation 38. It is recommended that detailed guidelines be developed for USAID to promote common approaches to locust and grasshopper control and safe pesticide use among UN Agencies and donor nations. Coordination of efforts is becoming increasingly important because of the increasing number and magnitude of multilateral agreements and follow up efforts in subsequent years by various donors.

This SEA supports this recommendation. Coordination must occur both at the AID/W level and the USAID/Botswana level. In Botswana, the PPD would not be the major coordinating body, and donors need to discuss specific plans with each other. These efforts should be improved for the future.

APPENDIX C.

1994 LOCUST CONTROL OPERATIONS, CHOBE DISTRICT

TABLE 1

INFORMATION BELOW IS FOR AFRICAN MIGRATORY LOCUST SWARMS INVADING BOTSWANA FROM NIGERIA

DATE	EXT. AREA	EXACT LOCATION	CHEMICAL USED	QUANTITY OF CHEMICAL USED (L)	AREA SPRAYED IN HECTARES
07/01/94	Parakarungu	Habozo..	Penitrothion 96%ULV	90	60
"	Satau	Honga		100	84
08/01/94	Satau	Hasanzu		30	29
	Parakarungu	Habozo		35	16
	Satau	Satau		50	40
09/01/94	Satau	Hasanzu	Deltamethrin 5% ULV	60	40
	Satau	Yambezi	"	50	50
10/01/94	Satau	Chida	Penitrothion 96%ULV	60	48
11/01/94	Satau	Satau		20	41
				Deltamethrin=140 P/thion=440	401

SUMMARY OF TABLE 1

	NO. OF SWARMS	HECTAIRE SPRAYED
Satau	8	325
Parakarungu	2	76

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Table 2

DETAILED TABLE SHOWING LOCUST CONTROL CAMPAIGN

Compiled by: S. Ranthoakgale
(P.P.O - Chobe)

DATE	EXT. AREA	EXACT LOCATION	TYPE OF LOCUST	STAGE OF GROWTH OR ACT. OF LOCUST	CHEMICAL USED	QUANTITY OF CHEMICAL USED in litres	AREA SPRAYED IN HECTARES	APPLICATION R.
19/12/93	Parakarungu	Kalundu	AML	Hoppers	Deltamethrin 5% ULV	45	29	1.6
20/12/93	Parakarungu	Kalundu	AML	Hoppers	Deltamethrin 5% ULV	35	27	1.3
21/12/93	"	"	AML+RL	"	"	40	21	1.2
22/01/94	"	"	"	"	"	30	18	1.7
24/01/94	Parakarungu	Kalundu	AML	Adults on Flyers & Hoppers	"	45	30	1.5
27/01/94	Satau	Kwetsi	RL	Hoppers	Fenitrothion 95% ULV	25	15	1.6
28/01/94	Parakarungu	Kweha	UIC	Hoppers and adults	Fenitrothion 95% ULV	100	36	1.1
30/01/94	"	"	UIC	"	"	30	12	1.6
	Parakarungu	Kalundu	AML+RL+UIC	Hoppers	"	120	75	1.6
31/01/94	"	Kweha	UIC	Hoppers and adults	"	120	30	1.5
	Parakarungu	Kalundu	UIC+AML+RL	"	"	195	77	1.1
01/02/94	Parakarungu	Kweha	UIC	Hoppers	"	90	48	1.3
02/02/94	Parakarungu	Kalundu	AML+RL+UIC	Hoppers	"	105	64	1.6
03/02/94	Parakarungu	Mabozu	UIC	Hoppers	"	195	110	1.7
04/02/94	Parakarungu	Mabozu	UIC	Hoppers	"	90	55	1.6
07/02/94	"	Kalundu	UIC+AML+RL	Hoppers and adults	Deltamethrin 5% ULV	30	13	2.5
08/02/94	"	"	"	"	Fenitrothion 95% ULV	60	38	1.6
09/02/94	"	"	"	"	"	60	40	1.5
11/02/94	"	"	"	"	"	60	38	1.6
14/02/94	"	"	"	"	"	30	18	1.6
15/02/94	"	"	"	"	"	30	20	1.5
18/02/94	"	"	"	"	"	45	21	2.1
20/02/94	Satau	Monga	RL	Hoppers	"	15	6	2.5
21/02/94	"	"	"	"	"	15	5	3.0
TOTALS						Deltam. = 2251 F/thion = 13751	973 ha	

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APPENDIX D.

BOTSWANA PPD VEHICLES Distribution of Plant Protection Vehicles - Countrywide

REGION	DISTRICT	TYPE OF VEHICLES	NO. OF VEHICLES
(Head Office)	(Gaborone, Sebele)	Hilux 4 X 4	4
		Pajero 4 X 4	1
		V 8 4 X 4	3
		Car 2 X 2	1
		Bus 2 X 2	1
		Truck	6
		Land Cruiser 4X4	5
		Nissan	3
		Hilux Twin Cap	1
Gaborone	Molepolole	Nissan 4X4	1
		Land Cruiser 4x4	1
	Ramotswa	Land Rover 4x4	1
	Mochudi	Hilux 4X4	1
	Lentsweletau	Land Cruiser 4x4	1
	Letlhakeng	Nissan 7 2x2	1
		Hilux 4X4	1
		Land Cruiser 4X4	1
Central	Serowe	Nissan 4x4	1
	Mahalapye	Hilux 4X4	1
	Palapye	Land Cruiser 4X4	1
	Machaneng	Hilux 4X4	1
	Bobonong	Hilux 4X4	1
	Selebi-Phikwe	Hilux 4X4	1
	Letlhakane	V 8 4X4	1
Francistown	Tonota	V 8 4x4	1
	Tutume	Nissan 4x4	1
	Masunga	Hilux 4x4	1
Maun	Gumare	Land Cruiser 4x4	1
	Maun	Land Cruiser 4x2	1
		Land Cruiser 4x4	1
	Chobe	Land Cruiser 4x4	2
Western	Hukuntsi	Land Cruiser 4x4	1
	Kang	Land Rover 4x4	1
		J6 Land Cruiser	1
	Gantsi	Land Rover 4x4	2

	Tsabong	Land Cruiser 4x4	1
Southern	Kanye	Hilux 4x4	2
	Mmathethe	Land Cruiser 4x4 Car 2x2	1 1
	Goodhope	Nissan 4x4 Land Cruiser J6	1 2
	Jwaneng	Hilux 4x4	1
	Moshupa	Nissan 2x2	1
TOTAL			63

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APPENDIX E.

PROTECTED AND PARTIALLY PROTECTED ANIMALS, BOTSWANA DWNP

PROTECTED GAME ANIMALS

Night-ape	Roan antelope
Pangolin	Vaal rhebok
Aardwolf	All pelicans
Brown hyaena	All herons
Cheetah	All egrets
Serval	All bitterns
Blackfooted cat	Hammerkop
Wild dog	All storks
Otter	All ibises
Honey badger	Spoonbill
Civet	All flamingoes
Antbear	Secretary bird
Rock dassie	All vultures
Yellow-spotted dassie	All falcons
Rhinoceros	All kites
Hippopotamus	All eagles
Giraffe	All buzzards
Klipspringer	All sparrowhawks
Oribi	All goshawks
Sharpe's steenbok	All harriers
Mountain reedbuck	All cranes
Waterbuck	Kori bustard
Puku	Stanley bustard
	All jacanas
	Fishing owl
	Narina trogon
	Python

PARTIALLY PROTECTED GAME ANIMALS

Leopard
Lion
Elephant
Chobe bushbuck
Sable antelope
Eland

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APPENDIX F.
RELEVANT DOCUMENTATION

FAO Pesticide Management Documents:

- a) International Code of Conduct for Distribution and Utilization of Pesticides.
- b) Guidelines for safe pesticide distribution, storage, and handling.
- c) Guidelines for pesticide disposal and container disposal.
- d) List of FAO approved pesticides.
- e) Pesticide storage and packaging guidelines.
- f) Guidelines for pesticide approval and management.
- g) Ecotoxicological guidelines.
- h) Ground and aerial application guidelines.
- i) Insecticide poisoning: prevention, diagnosis and treatment.
- j) Guidelines for effective labeling.
- k) Efficacy requirements for pesticide approval.
- l) guidelines on environmental criteria for the registration of pesticides

Other Documents on Pesticides and Locust/Grasshopper control:

- a) Guidelines for selection, procurement, and use of pesticides in World Bank-financed projects.
- b) Crop Protection Service Organization (D.310) T. 1. PRIFAS. Dec. 1988.
- c) Effectiveness of localized pesticide treatment. (D.309) T. 2. PRIFAS - Dec. 1988.
- d) Effects of locust and grasshopper control on the environment. (D. 308) T. 3. PRIFAS - Dec. 1988.

e) Locust and Grasshopper Control - Interministerial Instruction No. 3 related to protection of man and environment. Algérien doc.- March 1989.

f) First aid in cases of poisoning by locust and grasshopper control products. CIBA-GEIGY.

USEPA Pesticide Fact Sheets:

Acephate	# 140	October	1987
Bendiocarb	# 195	June	1987
Carbaryl	# 21	March	1984
Cholpyrophos	# 37	September	1984
Diazinon	# 96.1	December	1988
Fenitrothion	# 142	July	1987
Malathion	# 152	January	1987
Lindane	# 73	September	1985

These are among the many Pesticide Fact Sheets issued by the U.S. Environmental Protection Agency, selected for relevance to locust and grasshopper control. They summarize data known to EPA at the time of preparation of the Fact Sheet. They generally include information on acute and chronic toxicity to humans and other non-target organisms, handling precautions, and other instructions for use. They may be requested from:

Office of Pesticide Programs
US Environmental Protection Agency
401 M Street, SW
Washington, DC 20460 USA

AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR AFRICA
Disaster Response Coordination
AFR/AA/DRC

COUNTRY SPECIFIC SUPPLEMENTARY ENVIRONMENTAL ASSESSMENT (SEA)
TO THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (PEA)
FOR LOCUST/GRASSHOPPER CONTROL IN AFRICA AND ASIA

FINAL ACTION FORM

COUNTRY: BOTSWANA

DATE: October 1994

Recommendation:

ACTION TAKEN:

Approved: ✓

Date 11/28/94

Disapproval: _____

Date _____

Bureau Environmental Officer, John Gaudet:

Jeff. Gaudet